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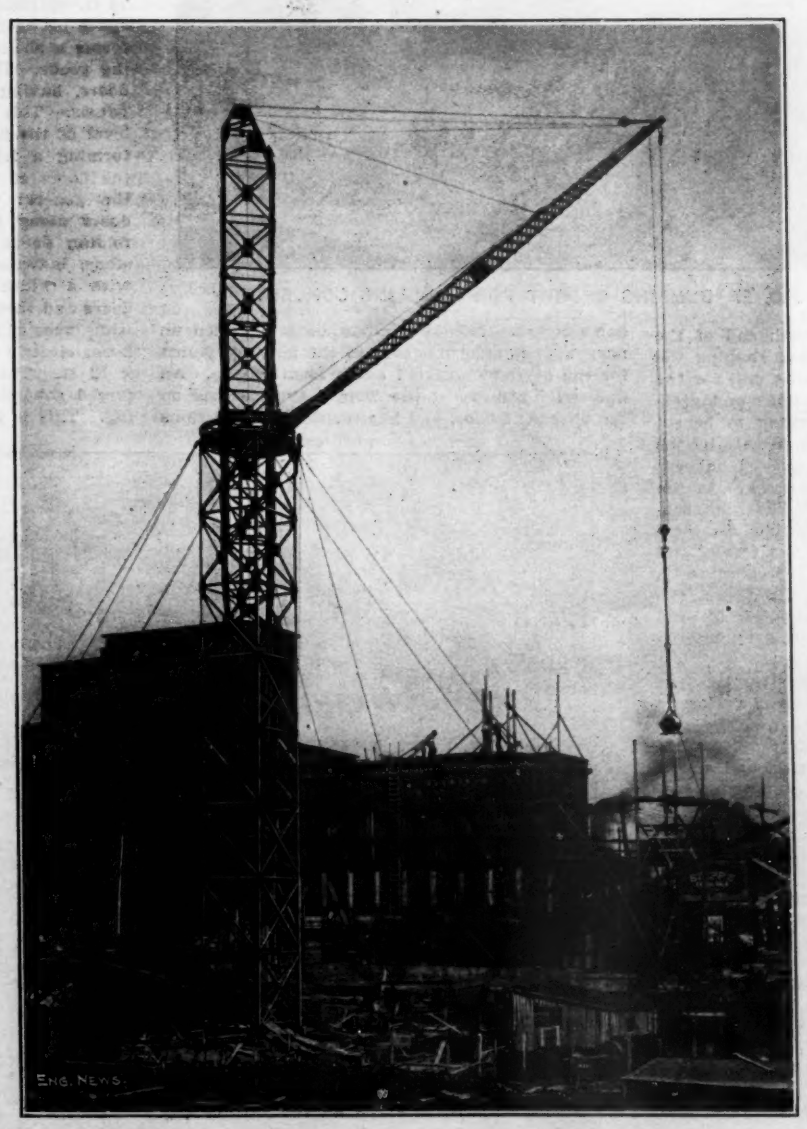
SPECIAL DERRICKS AND BUCKETS FOR THE CONSTRUCTION OF A REINFORCED-CONCRETE WAREHOUSE AT CHICAGO.

For the construction of the reinforced-concrete warehouse of Montgomery Ward & Co., at Chicago, a novel type of crane or derrick has been designed for use in connection with a carefully prepared system of handling materials. The building is located on the east bank of the Chicago River, with its south end fronting on Chicago Ave.; it will be approximately rectangular in plan, 750 ft. long, 150 to 270 ft. wide and 135 ft. high, having eight stories and a basement. It will be of monolithic construction, but with brick shafts for the elevators and stairways. The columns are spaced 17 ft. 6 ins. c. to c. in both directions, and carry a framing of main girders for each floor, but there are no intermediate ribs or beams in the floor panels.

The engineers required each floor to be built complete, not considering it desirable to omit any portion in order to leave room for construction towers or other apparatus. The quantities of materials to be handled are enormous, and the space left in which they can be handled is exceptionally limited. Under these conditions, special methods were necessary for handling the materials rapidly and conveniently. The plan adopted was to erect tall steel derricks which would cover the greater part of the area, and have their booms placed at such an elevation as to serve the entire height of the building. Each derrick has a tower 10 ft. square, built within the space of one floor panel. The reinforcing rods projecting through from the adjacent panels are bent up out of the way. When the work is completed, the towers will be taken down, the rods straightened, forms set in place, and the concrete filled in for the floor slab. The hoisting is done through the brick towers which form the elevator and stairway shafts. A portable railway system connecting these shafts with the concrete mixers, woodworking mill and iron mill, supplies the concrete, lumber and reinforcing bars, etc., to the derricks.



STEEL DERRICK WITH 135-FT. MAST AND 85-FT. BOOM USED IN THE CONSTRUCTION OF THE MONTGOMERY WARD & CO. WAREHOUSE AT CHICAGO.

These derricks are of steel construction throughout, as shown in Fig. 1. The mast is 135 ft. high, tapering from the foot to a height of 85 ft., above which it is about 6 x 4 ft. in section. This mast stands inside a fixed steel tower, 10 ft. square and 80 ft. high, with guy ropes attached to each corner. These guys are so arranged as not to foul any of the girder or column forms, and they will pass through pipe sleeves set in the floor slabs as the work progresses. At the top of the tower is a trussed ring, having two concentric webs with bracing between, and around the inside web is riveted a steel rail, placed horizontally. On the mast there is also a trussed ring, carrying vertical rollers which bear against the circular rail. The footstep is a hemispherical bronze casting held in a cast-iron base which is bolted to the foundation plate. On this bronze casting is seated a cast steel socket forming the base of the mast. The bull ring is placed above the tower, with the swinging cable led down outside the tower. This arrangement avoids the torsion which would result from placing the bull wheel at the foot of a mast of this height.

The steel boom is 85 ft. long, and can hoist to its full capacity (12 tons) when in a horizontal position. It can swing through a complete circle of 170 ft. diameter, and can hoist to a maximum height of 150 ft. above the ground, or 15 ft. above the roof level of the building. The hoisting and topping cables are led inside the mast, passing out at the base to the drums of a 25-HP. electric hoisting engine, which also has a drum for the swinging cable. Each derrick has its own engine. One great advantage of this type of derrick is that the boom can be revolved around the tower a number of times, to the limit of the number on wraps of the swinging table around the bull ring. This can be done without its being required to top up the boom or to change its elevation. The derrick is quick in operation and is said to require less power to revolve it than is required to revolve an ordinary guyed derrick with boom of equal length.

The four derricks serve the greater part of the area of the building directly, and hoist all of the materials used. In the spaces beyond their reach, the forms and reinforcing material are handled from the large derricks by small portable gin-poles, while the concrete is distributed by wheelbarrows, as noted below.

The method of handling the immense amount of concrete for this building in such a way as to enable work to be carried on expeditiously was a point that required careful consideration. As a result of this study dumping buckets of special design are used. One of these is shown in Fig. 2. These buckets are of 1½ cu. yds. capacity, so as to take an entire batch from the concrete mixer. It is desirable and convenient to handle the concrete in considerable quantities, so as to maintain a good supply on the working floor and to reduce the amount of hoisting. At the same time the direct dumping of such a quantity into place would put severe stresses on the forms. To provide against this, and also to facilitate depositing material in narrow forms, or in small quantities at different points, as well as to supply the wheelbarrows, it was necessary to have

some method of regulating the discharge from the bucket. The bucket is of steel, about 4 x 4 ft. on top, with a hopper shaped bottom; at one side of this hopper is a discharge spout, having the end fitted with a segmental gate which rocks on a horizontal axis and is operated by a lever at the side of the bucket. To the bottom of the bucket is attached a steel frame, making it self-supporting when detached from the hoist.

For filling the forms direct, the bucket is swung into position, and the gate operated to give a rapid or slow discharge of the quantity required. For supplying the wheelbarrows which serve the areas beyond the reach of the derricks, the buckets are set on tables or platforms about 3 ft. high. The wheelbarrows are run under the spout, and the gate enables them to be filled without waste or spilling of the material. Each platform is large enough to hold two buckets, the derrick placing a loaded bucket and taking away the empty one.

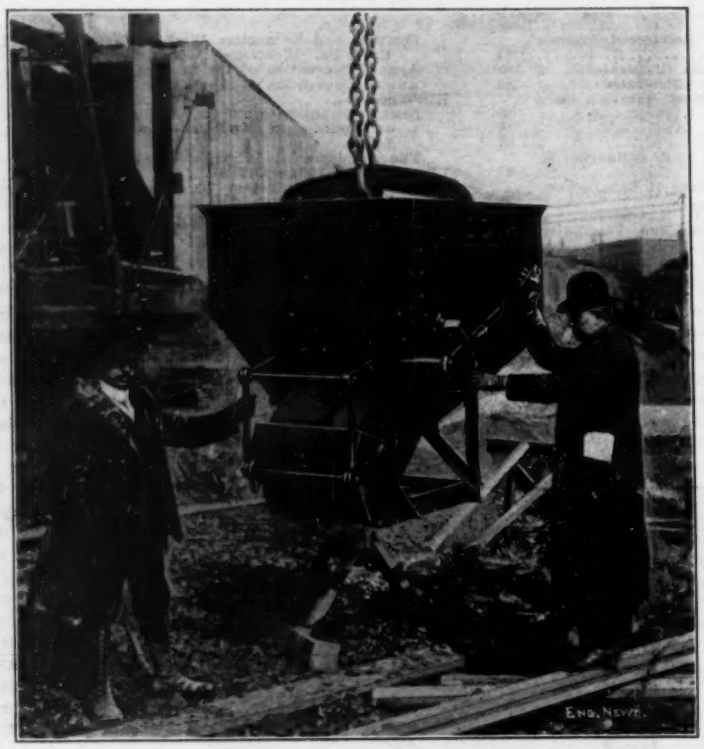


FIG. 2. DUMPING BUCKET FOR HANDLING CONCRETE.

An extensive construction plant has been installed at the site, and material is delivered on sidings from the Chicago, Milwaukee & St. Paul Ry., whose line runs close to the east side of the building. Adjacent to the north end of the building is a plant for bending and shaping the reinforcing rods, also a woodworking mill for the construction of the forms for columns and girders, which are built in sections ready to be set in place. The sections are hoisted directly by the derrick covering this yard, or conveyed on cars on an industrial railway of 24 ins. gage to the hoisting points of other derricks. The reinforcement for the girders is also assembled in complete sections ready to be set in the forms, and the spiral reinforcement for the columns is handled in the same way. On the floors, the forms and reinforcement are handled by the main derricks and by auxiliary derricks, as already noted.

At the east side, on the narrow strip between the building and the railway tracks, are storage bins, elevated above a side track. The railway cars loaded with sand and washed-gravel for the concrete are run on the side track and dump their contents into a hopper long enough for two cars. From side openings in the bottom of the hopper, the material is delivered as required to a horizontal belt conveyor; this discharges it upon an inclined conveyor, which again delivers it to a third inclined conveyor having trippers, and an end discharge to serve the different storage bins. The belt conveyors are of the Robins type, and the two inclined conveyors (22°) are driven from one shaft geared to a 35-HP. electric motor. A link-belt connection from this shaft drives the horizontal conveyor. From the bins the materials are delivered by gravity in proper quantities to a charging hopper, which feeds the concrete mixer. Cement in sacks is taken direct from cars and stored directly back of the mixer, and from there is thrown into the charging hopper by hand.

The above combination of conveyors and storage bins over the tracks was made necessary by the very limited space left for the contractor to handle the large quantities of materials to be used in the construction of the building. This space was limited to such an extent that it was even found necessary to shorten the frame of the mixer and to rearrange its driving gear in order to get it in place.

There are two principal mixing plants, one having a Ransome and the other a Smith machine, both of 1½ yds. capacity. Besides the above there is a smaller portable plant, having a Smith mixer. The concrete is delivered into the buckets already described. These are either hoisted direct from the mixer or are carried on narrow-gage steel flat cars to the hoisting points for the derricks situated away from mixers. An industrial railway of the Koppel type, is laid on the basement floor, and has turntable connections for the different tracks and branches. This serves for the distribution of material of all kinds to the shafts within reach of the derricks.

The firm of Richard Schmidt, Garden & Martin, of Chicago, are the architects and engineers and the George A. Fuller Co., of Chicago, has the contract for construction. The cranes and concrete handling buckets were designed for this work by Mr. Edgar S. Belden, who is General Superintendent of Construction for the contractors, and who also planned the general methods in carrying on the work.

A CONCRETE WAREHOUSE WITH CONCRETE DOORS AND WATER TANK.

The use of concrete for warehouse buildings is developing rapidly, and we illustrate herewith some of the specially interesting details of a large storage warehouse which was erected last year at Kansas City, Mo., for the Terminal Warehouse Co. The building is on Broadway, between 24th and 25th Sts., and is 100 x 130 ft. in plan, with five stories and basement. It is of monolithic construction throughout, including the roof tank, and even the doors are of concrete. The architects and engineers were Elzner & Anderson, of Cincinnati, O., who also supervised the erection. The contract was awarded to the Pittsburg Expanded Metal Co., Pittsburg, Pa. The total cost was approximately $85,000.

On the street level is a wide driveway with five 14-ft. entrances for wagons. This occupies the space between the first two rows of columns and forms a sheltered space for loading and unloading goods. The entrances are fitted with folding doors, having steel framing filled with concrete panels. This driveway is a few feet below the level of the first floor, the end of this floor thus forming a freight-handling platform level with the floors of the wagons. This may be seen in the general view, Fig. 1. The three interior doors along this platform are also fitted with folding doors. The front columns of the first story, between the driveways, are of T section, with a width of 4 ft. 6 ins. on the face; the doors and their operating apparatus fit behind the wide faces of the columns. The building has two 2-ton electric elevators, with platforms about 10 x 12 ft. There is one staircase, built of reinforced concrete and having gas-pipe hand railing. This is placed in a shaft behind one of the elevators, while a vent shaft is built beside the other elevator.

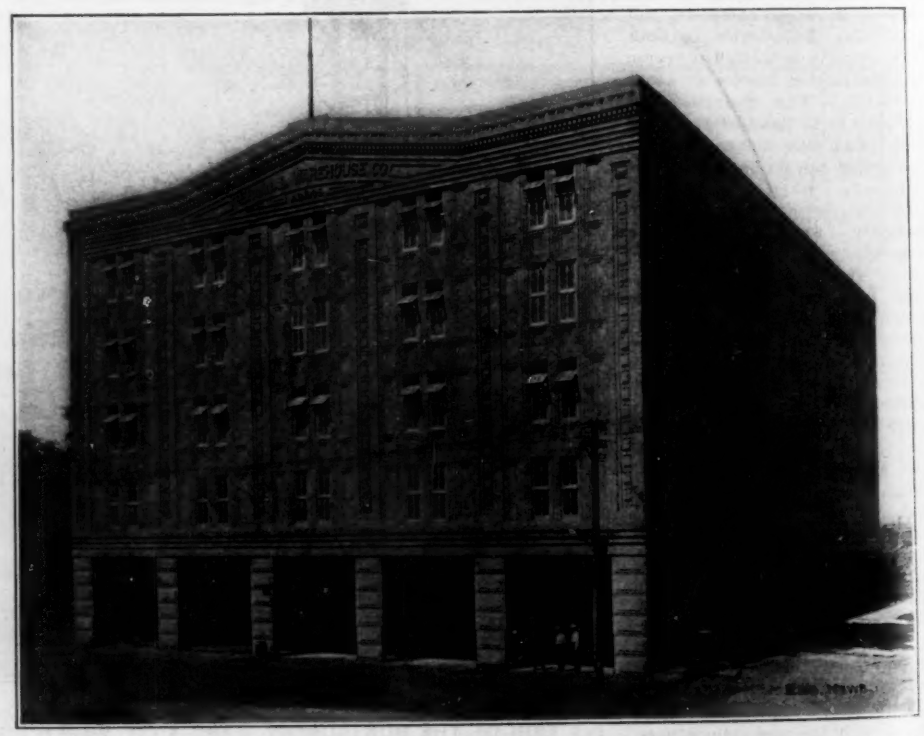


FIG. 1. REINFORCED CONCRETE WAREHOUSE FOR THE TERMINAL WAREHOUSE CO., KANSAS CITY, MO.
Elzner & Anderson, Cincinnati, O., Architects and Engineers.
Pittsburg Expanded Metal Co., Pittsburg, Pa., Contractors.

The architectural treatment of the face of the building is worth noting. As shown by Fig. 1 it

consists of simple moldings and a combination of raised and recessed paneling. A detail of some of this work is shown in Fig. 2. The moldings and panels are made with square sections and were produced by nailing boards and strips upon the inside of the forms. The exterior walls are finished with a coat of rich cement splashed on with a paddle so as to give a rough stippled finish. This preserves the characteristic appearance of the concrete and is found to be very effective.

All the columns are carried down to rock, at depths of from 8 ft. to 30 ft. below the surface, and have pyramidal footings. The column loads range from 180 to 300 tons at the base. The columns are spaced 16 ft. 3 ins. c. to c., lengthwise of the building, and about 19 ft. to 21 ft. apart transversely. In the basement there are subsidiary wall columns in the longer sides of the building, the main panels of 16 ft. 3 ins. being divided into three panels of 5 ft. 5 ins. c. to c. These support transverse girders or ribs at each floor, which are built into the main girders running lengthwise between the columns; thus each main panel of 16 ft. 3 ins. is subdivided into three panels 5 ft. 5 ins. × 19 ft. (or 20 ft.). The interior columns are square, 28 × 28 ins. in the basement, and 12 × 12 ins. in the top story. The wall columns are 30 × 18 ins. and the subsidiary columns 18 × 8 ins. at the bottom. The walls are 6 ins. thick (8 ins. for rear wall of basement)

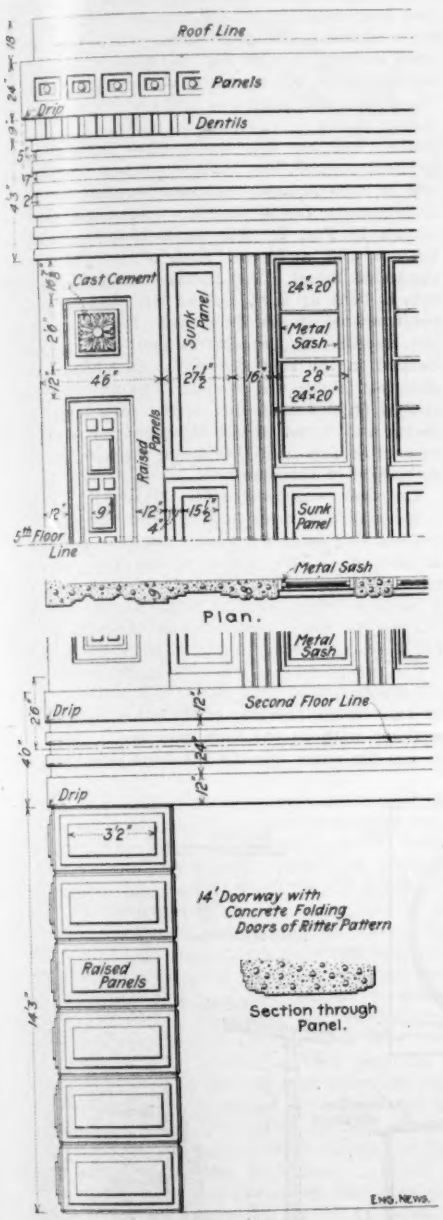


Fig. 2. Paneling and Decorative Treatment of Concrete Warehouse.

and their exterior faces are flush with the backs of the columns. They are reinforced with a continuous sheeting of expanded metal near the inside face, the sheets lapping 12 ins. At the backs of the columns there are also vertical strips of expanded metal near the outer face of the wall, the width of the strip being about twice the width of the column.

The steel reinforcement includes plain round bars for columns (with hoops at 12-in. intervals), twisted bars for girders and beams, and expanded metal sheeting for floors and walls. The vertical column bars were allowed to extend through any number of floors, provided that the splices occurred at or above the floor line, but no splices were allowed in the fifth floor. The bars were spliced with butt joints in sleeves 12 ins. long, ⅛-in. larger in diameter than the bars; the joint was grouted. The girders are reinforced by horizontal and inclined longitudinal twisted bars, but instead of transverse stirrups or U-bars for the reinforcement for shear, each girder has at each end a "basket" made by bending a sheet of expanded metal into U shape. The upper ends of the basket are bent over to lock with the expanded metal reinforcement in the floors. The main girders are 12 ins. wide and 28 ins. deep, the depth including the 4-in. floor slabs. The two ribs in each panel are 8 ins. wide and 22 ins. deep (also including the slab). The floors are given a smooth trowel finish like that of sidewalk work, and are so laid as to drain to outlets with 4-in. wrought-iron drain pipes leading to sewer connections, so that they can readily be washed down with water from a hose. The roof slab is 3¼ ins. thick and has only one beam or rib in the middle of each main panel. The girders are 6 × 21 ins. and the ribs 6 × 17¼ ins. (the depth including the thickness of the slab). The roof is made waterproof by a covering of composition felt and gravel roofing.

The entire construction was figured for an available live load of 300 lbs. per sq. ft. on the first floor and 250 lbs. on the upper floors. The specifications required tests to be made at an age of 60 days, under which the floors must sustain twice the specified load and not deflect more than 1-800 of the span. A panel on the first floor, 14 ft. 1 in. × 19 ft. 3 ins., with a column at the middle of each longer side was loaded with 129,967 lbs. of sand; the deflection two hours after loading was 0.0375-in., and the permanent deflection was 0.005-in. Another panel, 16 ft. 3 ins. × 18 ft. 1 in., with a column at each corner, was loaded with 149,220 lbs. of sand or 58,740 lbs. to each of the two intermediate ribs or beams in the longer dimensions of the panel. The total deflection 40 hours after loading was 0.1325-in. in the east beam and 0.1225-in. in the west beam;

FIG. 3. WHEELED BUCKET FOR TRANSPORTING CONCRETE.

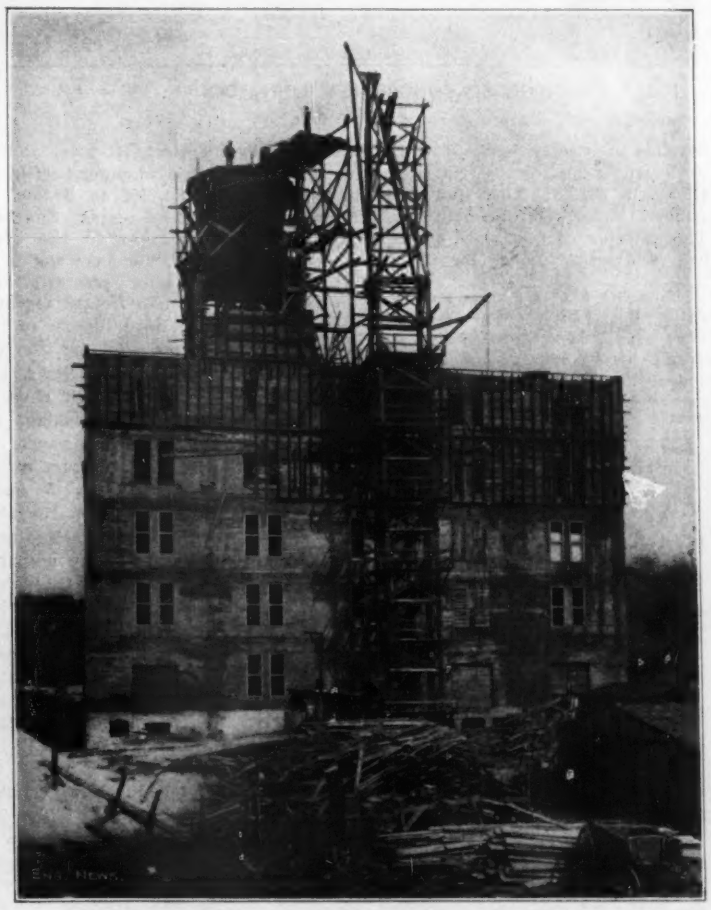


FIG. 4. CONSTRUCTION TOWER AND ELEVATOR FOR WAREHOUSE BUILDING, SHOWING ALSO THE CONCRETE ROOF TOWER AND WATER TANK.

the permanent deflection after removal of the load was 0.003-in. and 0.002-in. respectively.

The concrete was composed of Portland cement, sand and ¾-in. broken stone, in the proportions of 1 : 2 : 4. It was mixed quite wet and was handled in wheeled buckets which were raised by an elevator and easily run over the floors, as shown in Fig. 3. This view also shows the expanded metal reinforcement for the floor slab. The interior surface was made smooth by the use of dressed lumber for the forms. The exterior was given a splash coat of cement mortar. For handling the materials, a timber tower was erected at one side of the site, forming a shaft for an elevator and also carrying a derrick boom. On the outside of it were stairways and platforms, giving easy access to the work under way. The tower was high enough for the elevator to reach the level of the roof, and when the concrete tank had to be built above this level, it was extended by an A-frame carrying the lines of a hoisting engine by which material was raised to a platform level with the roof of the tank. This construction tower and the concrete tower and water tank, are all shown in Fig. 4, which also shows some of the wall forms in place.

FIG. 5. REINFORCED CONCRETE FOLDING DOORS ON SHIPPING PLATFORM.

The fireproof character of the building is one of its special features. All woodwork is entirely eliminated in the construction of this building, even the elevators having steel frames and steel cars. The interior partitions, including those forming the elevator shafts, are of concrete, 2 ins. thick, reinforced with expanded metal sheeting and with framing of small vertical channel bars; these bars are spaced 16 ins. c. to c. and are let into the floors and ceilings. The windows have heavy galvanized iron frames, and are double glazed with ¼-in. wire glass, so as to make a more effective fire stop than the ordinary single-glazed windows. The doors are a specially interesting feature, every door in the building being entirely of steel and concrete. The frames are steel channels, with a filling of cinder concrete from 1½ to 2 ins. thick, reinforced with expanded metal. The 14-ft. entrances to the driveway, the doorways on the shipping platform, and the two freight elevators all have doors of the Ritter folding system (Engineering News, May 4, 1905) which close up against the ceiling, and in which the panels are of the construction described. Fig. 5 shows these doors on the shipping platform. The same materials were employed for all doors throughout the building, including those for the numerous storage bins or compartments with which it is provided, and which are hung on hinges. These are shown in Fig. 6. All the electric wires are laid in iron conduits which were built into the concrete as the work progressed. While the building itself is considered entirely proof against interior or exterior fires, it is equipped with a complete sprinkler system to protect the contents in case of any fire starting in the goods stored in the building. The hangers for the sprinkler pipes are secured to the ends of horizontal bolts embedded in the concrete beams, with their threaded ends projecting at the sides.

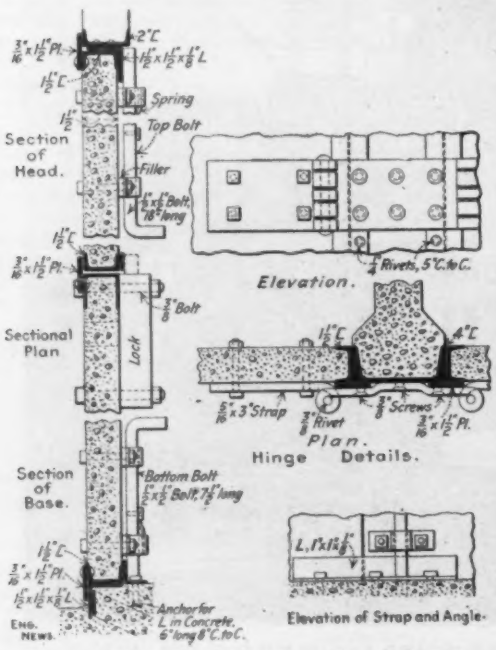


Fig. 6. Reinforced Concrete Swing Doors for Storage Compartments in Warehouse.

One of the interesting features of this building is the 25,000-gallon tank above the roof, which furnishes a gravity supply of water for the sprinkler system, floor washing, etc. Ordinarily tanks of this kind are of steel or wood-stave construction, but in this case it is of reinforced concrete and mounted on a concrete tower 51 ft. high above the main roof. The engineers state that this style of construction was adopted on account of the permanence and economy of the reinforced concrete, and that the cost of tank and tower was about 66% of the probable cost of a steel tower and tank of the same capacity. The tower has four columns 14 ins. square, forming extensions of the building columns. These support two deep girders 14 × 48 ins., between which are five cross beams all carrying a 4-in. platform. At about half the height of the tower are four horizontal struts, 6 × 24 ins., connecting the four columns; and all the struts have gusset web or bracket connections to the columns. The methods of construction and arrangement of the reinforcement for both the tower and tank are shown in Fig. 7. The tank has 6-in. side and bottom and a 3½-in. roof, all reinforced with expanded metal. The metal sheeting in the bottom is bent up 2 ft. around the edge so as to be incorporated in the side wall. In the same way the sheeting in the side is bent over to be embedded in the roof concrete. In addition to the sheeting, there are hoops of twisted steel bars, spaced from 4 to 6 ins. apart, each hoop in two pieces and wired to the expanded metal at intervals of 36 ins. All this metal work is, of course, embedded in the concrete.

The tank was built after the concrete platform upon which it rests had set and hardened. The bottom and sides were built together and the roof afterwards. The concrete was composed of 1 part Portland cement, 1½ parts loamy sand and 3 parts of ¾-in. stone. While it was still green the forms were removed and three ¼-in. coats of cement plaster applied, each being applied while the preceding coat was green. The plaster for the first coat was a 1 to 1 mixture, with 10% of lime in the cement; in the other coats a 1 to 1 mixture without the lime was used. After being in use for some months the tank developed some leaks in the sides, near the bottom, but these were closed by the application on the inside of a coat of Medusa waterproof cement.

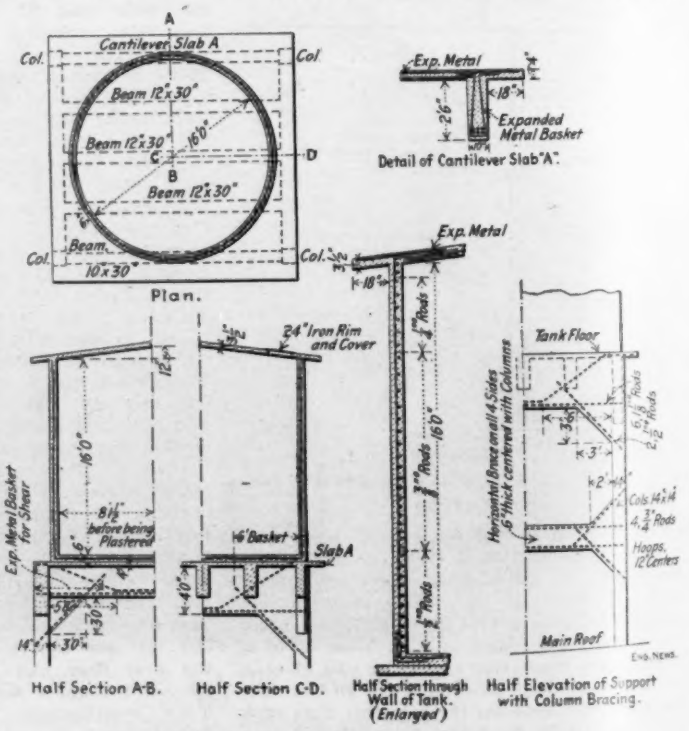
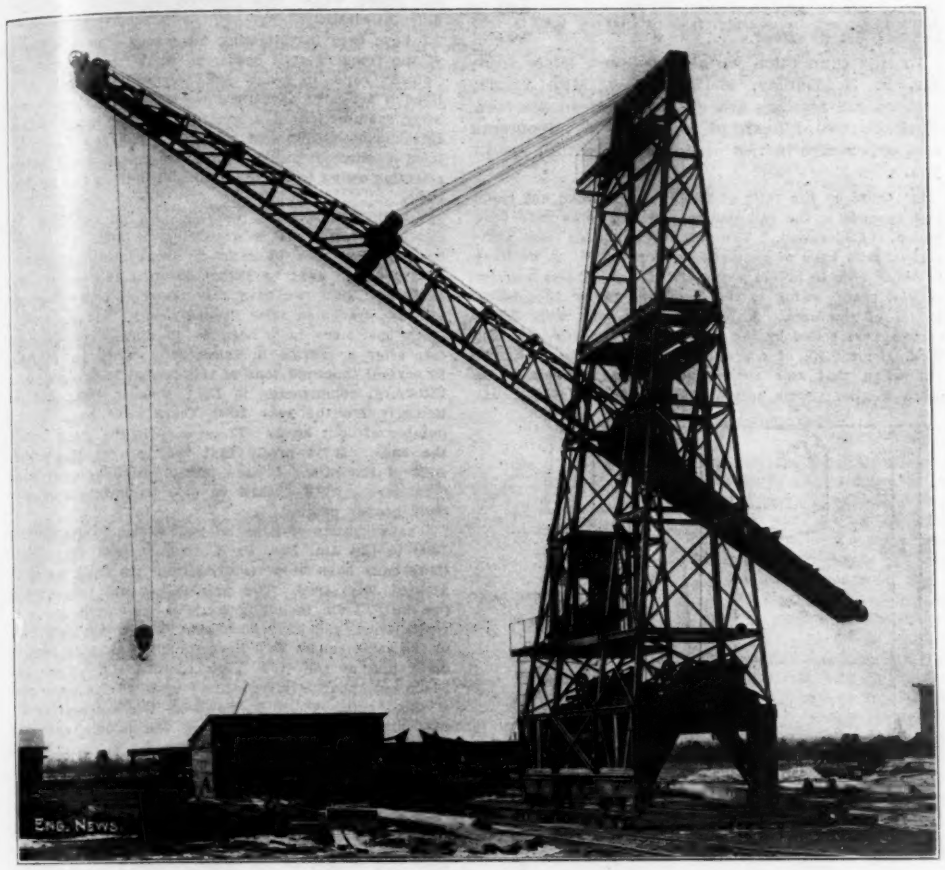


FIG. 7. CONCRETE TOWER AND WATER TANK.

ELECTRIC FREIGHT HANDLING CRANES FOR THE PANAMA RAILWAY.

Some electric traveling cranes of interesting design have recently been built for the Panama Ry. for the purpose of handling freight between ships and warehouse at the La Boca pier of the Pacific terminal. They have to operate on a narrow space between the warehouse and the edge of the pier, and have also to provide for a tidal variation of 20 ft. in water level. Eight of these cranes have been built and equipped complete by the Shaw Electric Co., of Muskegon, Mich. The accompanying cut shows one of the cranes erected in the builder's yard.



ELECTRIC FREIGHT HANDLING CRANE FOR THE PANAMA RY.
Shaw Electric Co., Muskegon, Mich., Builders.

The crane has a steel tower in which is pivoted an 80-ft. boom, the outer end of which can carry loads over the decks of the largest vessels at high tide, while the inner end is low enough to project inside of the warehouse doors. The boom can be raised to an almost vertical position, so as to clear the warehouse and all parts of ships while the crane is traveling, or when ships are being brought up to the pier. In this position, the top of the boom is about 90 ft. above the pier. The total weight is about 50 tons.

The tower is 62 ft. high above the rails, and has a clear opening through it, 10 ft. wide, in which the boom is suspended and through which the loads are carried by a hoisting trolley running in the boom. The base of the tower is so constructed that the crane can travel over freight piled to a height of 6 ft. between the rails, and so that goods may be trucked directly from under the crane to the warehouse. The space between the front of warehouse and edge of wharf was only sufficient for a track of 11 ft. gage. This, together with the requirements as to height and reach, made the question of stability a serious one. Although the weight of frame and machinery has been so disposed that the crane will be stable with a load 25% above normal capacity in the extreme position, clamps have been provided which are always engaged with the rear rail, so as to prevent the crane from tipping if a load should become fouled on a hatchway or other part of the vessel while being hoisted. The crane is mounted on six wheels, four under the front and two under the rear side of the tower. In view of the possibility of uneven track due to settling of the pier, the wheels are carried in equalizers, so arranged as to compensate for any probable irregularities of track without straining the structure.

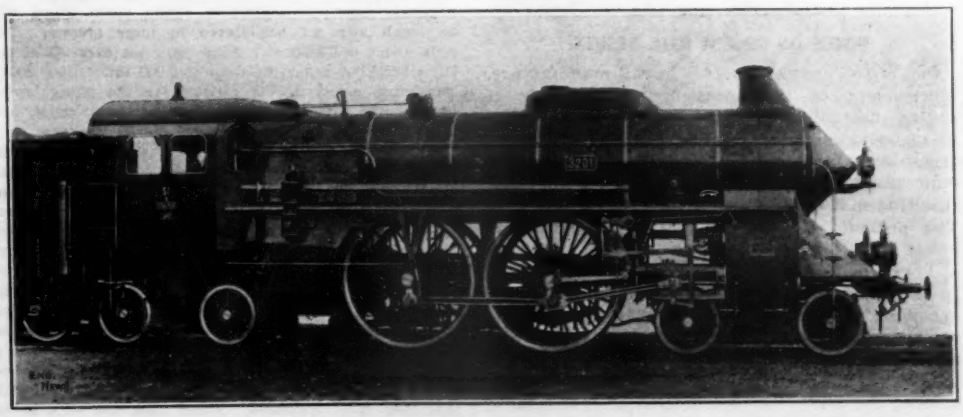
The machinery for the various movements is placed in the base of the tower, adding to the stability of the crane, and giving easy access for inspection. For convenience in shipping and erecting, each set of machinery is mounted upon a separate frame, which is easily handled and put in place. The hoist is operated by a 65-HP. motor, the rack motion by one of 40-HP., and the travel and boom hoist motors are of 24-HP. and 8-HP. respectively. Automatic switches are provided to prevent over-travel in hoisting and racking out, also an overload switch for the hoisting machinery. All movements are under the control of one operator, whose cab is so located as to give him a good view of his work.

The crane has a regular working capacity of four tons, and a reach of 40 ft. from the center line between rails to the extreme outer position of the load. The total height of hoist is 70 ft. The speed of hoisting with full load is 150 ft. per minute, and the load can also be racked out and up at the same speed. The other two movements, travel and boom hoist, are relatively slow, being required only in setting the crane in position for service.

PASSENGER LOCOMOTIVES OF THE 4-4-4 TYPE WITH BAR FRAMES: BAVARIAN STATE RAILWAYS.

Some notable engines for fast service with heavy passenger trains have recently been introduced on the Bavarian State Railways, of Germany, and embody a number of features of special interest. One of the most striking of these features is the use of the American type of bar frames, which has in recent years been adopted for special reasons on locomotives in Germany and Denmark. The Bavarian State Railways have for some time been using four-cylinder balanced-compound engines of the Atlantic (4-4-2) and ten-wheel (4-6-0) types for fast passenger service, and these were so designed that their principal parts (including the boilers) were interchangeable. This necessitated the use of a narrow firebox to fit between the rear driving wheels of the ten-wheel engines. The builders, therefore, adopted the bar type of frames on account of their being so low that the firebox could be placed above them and thus be given the maximum available width, allowing only the necessary clearance between it and the wheels. With this arrangement a grate area of 35.30 sq. ft. was obtained. Some later engines of the Atlantic (4-4-2) type, however, for the Baden State Railways, had boilers with wide fireboxes giving a grate area of 41.64 sq. ft.

A new type of engine was then built for the Bavarian State Railways as a compromise between these two designs of Atlantic engines. In this the grate area is increased to 50.57 sq. ft. The total weight is also increased to 84 tons, but as the permissible weight on the driving wheels is limited to 32 tons, it was necessary to place a four-wheel truck at each end of the engine, making it of the 4-4-4 class. This arrangement was proposed some time ago by Mr. D. Van Alstyne, then Superintendent of Motive Power of the Northern Pacific Ry., in view of the increasing size of the firebox and total weight of modern locomotives. This is the first time, however, that it has been actually employed in ordinary types of engines for main line service. It may be noted that some suburban tank engines of the 4-4-4 type have been used on the Northern Ry., of France; and also passenger tank engines of the 4-6-4 type for fast trains on the Madrid, Saragossa & Alicante Ry., of Spain. One of the new 4-4-4 passenger engines of the Bavarian State Railways is shown in the accompanying cut.



FAST PASSENGER ENGINE OF THE 4-4-4 TYPE, WITH BAR FRAMES; BAVARIAN STATE RAILWAYS, GERMANY.
J. A. Maffei, Munich, Germany, Builder.

The boiler has a wide firebox with flat crown-sheet supported by vertical stays from the cylindrical shell. The ashpan is in three parts, one between the frames and one on each side. The dome is very low and placed near the front end

of the boiler barrel. In accordance with general practice on this railway system, the engines are fitted with "wind splitters" for the purpose of reducing the head-end wind resistance. Thus the dome and sandbox are enclosed in a single casing with a wedge-shaped end; the smokestack has a wedge-shaped casing in front, the smoke-box has a conical door; a wedge-shaped casing is placed in front of the cylinder saddle, and the cab has its front end extended in an inclined direction along the boiler. The engines are fitted with the Schmidt type of superheater. The frames are of the American double-bar type, with rigid cross frames, and carrying a vertical diaphragm or plate which supports the barrel of the boiler while permitting it to move freely in contraction and expansion. Behind the rear driving axle are plate frames extending beneath the cab.

The four cylinders all operate the front driving axle, with the cranks of each pair set at 180°. Each cylinder is served by a piston valve, but the two valves on each side are operated from a single Walschaert valve gear on the outside of the driving wheels. Attached to the rear end of the coupling rod is a lever operating a speed recorder in the cab. The driving springs are placed beneath the boxes and are connected to equalizing levers. The front and rear trucks have plate frames, and all their wheels are fitted with Westinghouse brakes. They have a lateral movement of 2.8 ins., controlled by springs. The tender is also mounted on a pair of trucks. The engines can pass around curves of 600 ft. radius.

These interesting engines were built at the Hirschau Works of J. A. Maffei, at Munich, Germany, to whom we are indebted for photographs. Our description is taken from an article by Mr. Maurice Demoulin, Engineer of Motive Power of the Western Ry., of France, in the "Revue Generale des Chemins de Fer," and is supplemented by information furnished by the builders. The general dimensions are as follows:

Driving wheels	7.21 ft.
Truck and tender wheels	3.30 "
Distance c. to c. of engine trucks	31.32 "
Wheelbase, driving	7.61 "
Total engine	38.37 "
Tender	17.71 "
Engine and tender	60.68 "
Length over engine and tender	69.30 "
Width over engine, extreme	10.10 "
Weight, on drivers	32 tons
Engine (empty, 76 tons)	84 "
Tender (empty, 19 tons)	52 "
Tractive power	11,000 lbs.
Cylinders, h.p. (2), inside	16.4 × 25.6 ins.
Cylinders, l. p. (2), outside	24.4 × 25.6 "
Cylinder proportions	1 to 2.21
Tubes: No. 208; length	13.12 ft.
Heating surface: Tubes	2,141.24 sq. ft.
Firebox	176.46 " "
Total	2,317.70 " "
Superheating surface	404.57 " "
Grate area	50.57 " "
Height, rail to top of smokestack	15 ft.
Water in tender	6,870 gallons
Coal in tender	7 tons

NOTES ON RECENT RAIL DESIGN.

One of the present troubles in rail manufacture, independent of the unsatisfactory methods of rolling now in force, is the high percentage of phosphorus in the metal. This is especially the case in high-carbon rails, the combination of high phosphorus and high carbon percentages resulting in a steel of doubtful character for rails. The present allowable limit for phosphorus is about 0.1%, for while some specifications call for a lower percentage, these are rarely observed. In fact, some broken rails have shown over 0.1% in combination with about 0.6% of carbon. As much of the available ore in this country is high in phosphorus, and as the Bessemer process does not permit of any extensive elimination of this in making the steel, the open-hearth process is now being resorted to as a means of improvement.

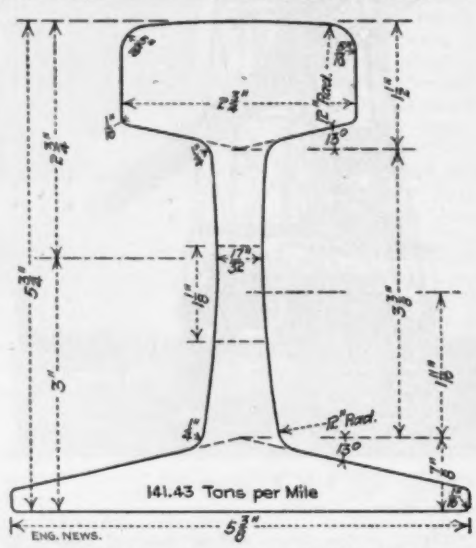
Open-hearth steel rails are not as yet in extensive use, but some large orders for such rails have recently been placed by the Union Pacific Ry. and Southern Pacific Ry. with the Colorado Iron & Fuel Co. and the Tennessee Coal, Iron & Railway Co. The rails will be of the railway companies' standard sections, for 75 and 90 lbs. per yd. The 90-lb. rail is shown in the accompanying cut, and the 75-lb. rail is of the same type, but only 5 ins. high and wide. We are indebted to Mr. J. Kruttschnitt, Director of Maintenance and Operation of these two railways, for drawings of the rails and for the requirements as to chemical composition, which are as follows:

OPEN-HEARTH RAILS FOR THE UNION PACIFIC RY. AND SOUTHERN PACIFIC RY.

	75-lb. Rails. Per cent.	50-lb. Rails. Per cent.
Carbon	0.51 to 0.61	0.58 to 0.72
Phosphorus, not to exceed	0.06	0.06
Silicon, not to exceed	0.20	0.20
Manganese, not to exceed	0.75 to 1.00	0.80 to 1.05
Sulphur, not to exceed	0.06	0.06

In this connection we give below a letter from Mr. P. H. Dudley, M. Am. Inst. Min. Engrs. (whose rail sections are the standard on the New York Central Lines), in regard to developments and experience in rail manufacture within recent years.

In regard to the rails of my design, I have not made any changes in the rail sections, though some have been under consideration. The specifications for the high-carbon rails have of necessity been modified, as we have not been able to obtain any rails of high carbon now for several years, owing to the large amount of phosphorus in all of the ores. A few thousand tons with 0.55% carbon were rolled by the Lackawanna Steel Co. in 1904. With about 0.4% of copper the rails were fairly tough, but when that was reduced the metal seemed to be more fragile. Some rails were rolled with 0.50% carbon, but that has since been reduced to 0.45% for 100-lb. rails. The phosphorus in the ores seems to increase slightly, and with that the increase in sulphur has been marked.



Section of 90-Lb. Open-Hearth Rail for the Union Pacific Ry. and Southern Pacific Ry.

A singular feature with the present ores which may be procured for rails, especially with the rolling and the inferior work upon the straightening presses, is that it seems almost impossible to obtain metal which will be tough and not be injured in these presses. The rails under the drop test stand well, not over 2% of the butts breaking under the drop of 2,000 lbs. falling 20 ft. The same metal in the rails under the straightening presses will receive some injuries by the gagging, and fractures occur after the rails are put in the track.

A number of tensile tests of the high-phosphorus metal (that is, with 0.10%) have been made, and the metal carefully examined after the tests. It has been observed in all countries that the high phosphorous metal apparently gives a good elongation, 17 to 18% per inch in 2-in. specimens, but the contraction of area is exceedingly small, only about half the usual percentage of metal much lower in phosphorus. I examined under the microscope a number of these specimens which had been tested, and it was apparent that the elongation was principally by the separation of the crystals, rather than a reduction of their size in the testing machine. I found several minute checks between the crystals, showing that they have separated. These tests are soon to be repeated upon metal which has been pulled to produce about 1% elongation, in order to see if the crystals have separated with that elongation. The fractures of these high phosphorus rails in the track at low temperatures (zero and 20° below) indicate that by shock the rails are checked long before the full elastic limits of the steel (as shown by the testing machine) has been realized in the stresses. The metal in the thin layers in the base, which is compressed in the different passes, seems to check as independent layers under the shocks in the track. This can be partially understood when it is considered that these rails have withstood many thousand repetitions of stress before final fracture. We find in many cases that the checks have two or three different stages of oxidation, showing that they are detailed fractures. It is rare to find fractures which are entirely fresh, without some preceding minute check in the base of the rail. This is particularly true after two or three years' service in the track. This refers entirely to fractures which occur in the base or head of the rail in apparently solid metal. The piped rails and those which split transversely belong to entirely different classes.

I have been investigating for a long time the question of the frequent split heads, or what the trackmen term "piped" rails, in nearly solid segregated metal. I outlined a series of investigations upon a hypothesis made after examination of a great number of specimens, and this has been confirmed within the last few days. It is from a source of defects which has not received sufficient attention owing to the difficulties of making the investigations.

My sections are still the standard on the New York Central system. It is gratifying to state that out of over 500,000 tons of rails in these sections, made at Bethlehem in 1891 to 1893, and then at Scranton from 1892 until 1903, we have only found 17 or 18 specimens of what trackmen term "piped" rails. Six or seven of those specimens have been found during the past winter, after a service in those rails of 12 to 14 years. In several thousand tons of rails rolled to my sections at Pittsburg, commencing in 1898, then in 1899, and particularly for the year 1900, there have been found a number of split heads. These open in the track between the ends. It is rarely that they are at the extreme ends of the rails. I have termed these "pocket pipes" temporarily, until I shall be able to designate them by their proper name.

I have reports of a lot of rails rolled in Pittsburg in 1900 to the Am. Soc. C. E. sections, and over 10% of those rails have been removed from the track up to the first of July, 1906. The composition was prescribed by the mill. I am including some of these rails in my investigations, and have been able to trace the split heads to the same causes as I have found in sections upon the main line of the New York Central Ry. These split heads are apparently segregated metal in the upper parts of the ingots. There is, however, less segregation with the split rails that come from the middle and lower parts of the ingot. The splits are not confined entirely to the rails from the top of ingot but may occur in any rail from the ingot. In the work at Scranton I had the rails from the ingots all lettered, the top rail A, the second rail B, and the third rail C. We can find those letters upon the rails now in studying the comparative wear and defects of the ingots. The A rails show the most rapid wear, and in some places after 12 years' service the A rails have had to be removed from the track, from increased wear and defects, while the B and C rails were in fairly good condition. It would be important to have all rails from the ingots lettered, then their comparative wear could be studied in the track. We should find that defects which we attribute to the top rails are distributed more extensively in rails from other parts of the ingots.

In the rails which I made at Bethlehem and at Scranton the phosphorus was limited to 0.06% and the sulphur to 0.07%. I should be pleased were it possible to make several hundred thousand tons of rails as high in carbon and low in phosphorus, for present service. The rails of that grade which are in the inbound track at the Grand Central Station, New York, have now carried about 350,000,000 tons of traffic, and were it not for the changes in the yard they would easily carry 150,000,000 more and remain quite smooth. The facing ends of the rails are not worn more than the trailing ends, except at one or two joints. In frogs, they last 2½ years, while the present rails we are getting sometimes do not give a month's service, and the average is only about three months.

The 75-lb. rails which I made at Bethlehem for the Mohawk & Malone Ry., about 33,000 tons, are nearly all in service, and only four or five fractures occurred the past winter. Those were all made in small ingots and with only two rails to the ingot, nearly one-third of the ingot being discarded. The heads of the rails do not show traces of defects in the ingots, the metal being solid and sound. That is the important requisite needed in our present rails, that the ingots should be sound and solid, then the subsequent work of rolling would ordinarily give us a metal of physical properties which would stand the intensity of the wheel contact pressures of our present loads and also distribute them safely as girders.

EYESIGHT TESTS FOR CHAUFFEURS are being agitated in Germany. The movement has the support of medical practitioners and government officials, who point out that such tests are compulsory for railroad men; while motor-car drivers are given certificates after merely proving their ability to manipulate the mechanism of an automobile, without inquiry as to whether they may not be short-sighted or color-blind.

TWO RECENT DESIGNS OF CATTLEGUARDS.

In most modern forms of cattleguards, the principle is to employ longitudinal bars, slats or ridges, to form a surface upon which cattle cannot get a footing. Many designs have been made embodying transverse ridges, usually formed by some form of apron covering the ties, the idea being that such an arrangement would be a greater deterrent to the wandering propensities of cattle straying on the roads. In the accompanying cuts, Fig. 1 represents a new cattleguard of this latter type, in which an inverted V-

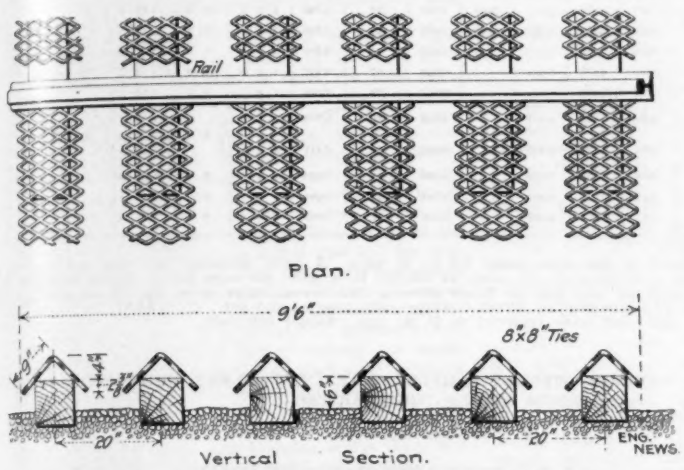


FIG. 1. A CATTLEGUARD OF EXPANDED METAL.
Climax Stock Guard Co., Chicago, Makers.

apron of expanded-metal is placed over each tie and projects below the edges. This has the advantage that each tie is independent of the others, and the work of lining, surfacing, ballasting, etc., can be done without removing the cattleguard, as must be done where the cattleguard extends longitudinally over several ties. By using ties 8 × 8 ins. and shoveling out the ballast from between them the depth is somewhat increased, adding to the efficiency. Where ordinary ties are employed, the arrangement shown could be equally well applied.

It is claimed that should an animal attempt to cross, its legs would be struck by the projecting points of the apron, while at the same time it would not be held in such a way that it could not withdraw its leg or be liable to trip and fall on the track. The size of mesh is such as to prevent the hoofs of small animals from going through, but does not afford them a foothold. Tests are said to have shown that the device is effective in checking cattle. This cattleguard is the invention of Mr. F. W. Stewart, Manager of the Climax Stock Guard Co., of Chicago, and has already been put in use for trial on different railways.

Ordinary farm cattle are as a rule easily checked by cattleguards, but with range cattle it is a different matter. Fig. 2 illustrates a more elaborate form of cattleguard specially designed to meet the latter difficulty. It was invented by Mr. W. H. Kennedy, lately Chief Engineer of the Oregon Railway & Navigation Co., and after having been in use for some years it has now been adopted by that road as its standard. For drawings and information we are indebted to Mr. J. P. Newell, Division Engineer, who states as follows in regard to the efficiency of the design: "These guards have proved effective in turning range cattle, which will crawl under a barb-wire fence or climb a tree in search of feed."

The Kennedy cattleguard is composed of cross timbers 6 × 16 ins., set on edge and bolted together, with spacing blocks 6 × 6 × 16 ins. between the ends and under the rails. Strips of barbed wire are laid across the timbers (parallel with the rails) and are secured by slats of triangular section spiked on top of the timbers. On the gage side of the rails these slats are cut away to leave clear flangeways. The cattleguard is a complete structure in itself, and is set in place on the ground or ballast, ready for the rails. As no ballast is filled in between the cross timbers, these form a series of deep and narrow pits, so that an animal attempting to cross can find no foothold even if the barbed wire and the sloping faces of the slats were not in themselves sufficient to discourage the attempt.

FOUNDATIONS FOR HEAVY STRUCTURES IN DEEP ALLUVIAL SOIL.*

By JOHN F. O'ROURKE, M. Am. Soc. C. E.

SUBJECT FOR DISCUSSION: (a) What is the best system of construction for foundations of heavy structures on ground such as that of the City of Mexico, which is an alluvial deposit about 300 ft. in depth, and similar in character to that at New Orleans?

(b) Will iron or steel used in foundations, independently or in combination with other materials, last indefinitely when in direct or indirect contact with water?

(c) Will the strength and durability of concrete in foundations be affected if before setting there is: (1) an excess of water; (2) lack of compression; (3) too rapid desiccation?

In the three questions submitted in connection with "Foundations," the first calls for the design of systems of construction applicable to the foundation of heavy structural work in the City of Mexico, the ground being an alluvial deposit, about 300 ft. in depth, similar in character to that at New Orleans, and taking into account the supporting power of the more or less unreliable material upon which the structure must be carried; while the other questions relate to the durability or strength of the materials in the foundation structure itself, and the manner in which they are placed, without reference to the character of the material upon which the structure is carried.

In regard to the first question, assuming that the material is as stated, namely, alluvial deposit having no very great bearing ability, one can approach it from a more general point of view than the question itself suggests. Every railroad engineer has had more or less to do with the carrying of structures or embankments upon swamps and other soft ground, and the ways by which this has been accomplished successfully are so numerous, and oftentimes so simple and well known, that its solution, with regard to carrying heavy structures in the City of Mexico, involves but another form of a very old problem.

It must be borne in mind that soft ground possesses varying powers of resistance to pressure, dependent very largely upon the degree with which it is confined. There are two ways in which the best results are obtained. One is to place the foundations at such a depth below the surface that the surrounding superimposed weight of the material itself prevents the ground from rising; and the other is by the use of one or another form of column to transfer the weight, through the friction on its sides, to the underlying material; enough surface to be brought into such contact to distribute the weight and reduce the stress to that which the material can bear without further movement.

It is not necessary to go into lengthy discussion of either system, since both are well known. The writer has built culverts, and even heavy bridge piers and abutments, upon material into which a man would sink if he attempted to stand upon it, by simply distributing the weight over an area which acted as a whole, because the structure was sufficiently strong to act as a unit in applying the pressure. No formula or rule seems to be applicable by which this area can be fixed, nor can the united resistance which soft ground offers under such conditions be always accounted for, but it is known by experience that material little different from mud will sustain pressure up to 1 ton per sq. ft. after the initial settlement has taken place, when the area involved is considerable and the loading has been uniformly applied over the whole surface. The same is true of the column system, of which the most familiar example is the ordinary wooden pile. It is a common experience, in building trestles across swamps and marshes, to find that a pile which can hardly sustain its own weight when driving has ceased, will, in a few days, take such a "set" that several heavy blows of the pile-driver hammer are necessary to start it again, and when started it will drive about as easily as before, until the harder material is reached; the fact being, however, that given a reasonable penetration in the soft material, the subsequent stability of the pile is not increased very much by its support upon solid bottom. The writer calls to mind, in particular, the case of the foundation piles in the falsework of the Poughkeepsie Bridge, where piles were driven 100 ft. below the surface of the water into 60 ft. of silt, and were loaded with from 10 to 20 tons each during the erection of the fixed span, and in which no settlement was noticed during the erection of that span. When the first fixed span was completed, the falsework was taken down, and the piles were pulled out and used again in the erection of the second fixed span, the interesting fact developing that a dozen heavy blows of a 6,000-lb. hammer were necessary before a pile could be started, after which it drove easily and was then readily pulled out.

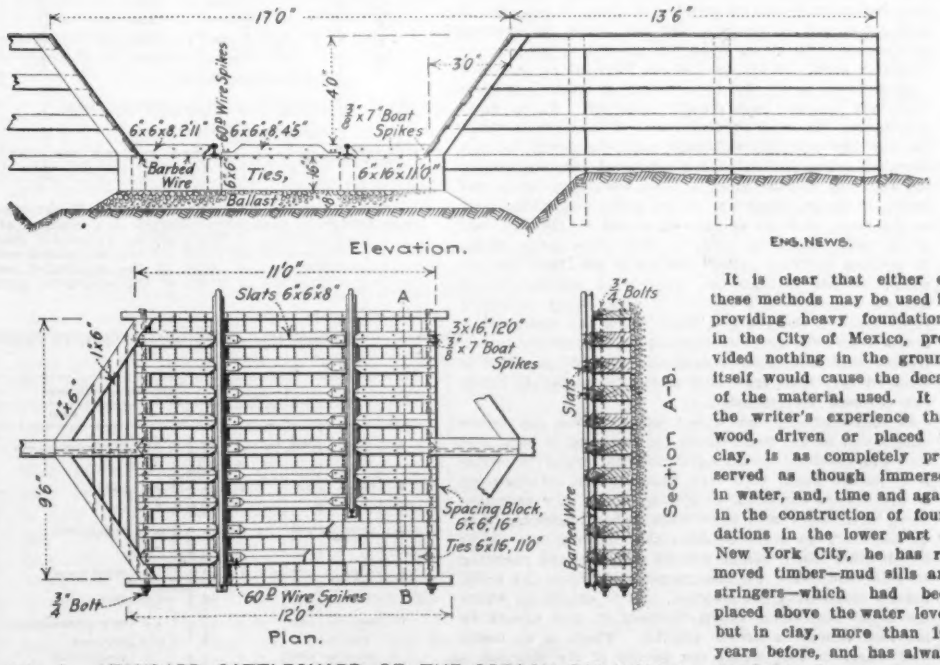


FIG. 2. STANDARD CATTLEGUARD OF THE OREGON RAILWAY & NAVIGATION CO.

It is clear that either of these methods may be used in providing heavy foundations in the City of Mexico, provided nothing in the ground itself would cause the decay of the material used. It is the writer's experience that wood, driven or placed in clay, is as completely preserved as though immersed in water, and, time and again in the construction of foundations in the lower part of New York City, he has removed timber—mud sills and stringers—which had been placed above the water level, but in clay, more than 100 years before, and has always found them in good preservation where such conditions existed.

As the question of materials enters largely into the choice of the system to be used, if suitable wooden piles are not available, concrete or steel could be used, the choice resting on economic rather than engineering considerations. This is true of the "distributed pressure" system, also, using the three materials separately, or in combination, as may be found most economical or substantial for each case.

*Opening paper of an informal discussion at the annual convention of the American Society of Civil Engineers, Mexico City, Mex., July 10, 1907.

Iron and steel used in foundations, apart from conditions where electrolysis may occur, last indefinitely when in direct or indirect contact with water, provided the water remains unchanged. The reason for this is obvious. Water attacks iron or steel on account of the oxygen it contains, and, if this is a proportionately small quantity, the amount of oxygen contained in wet concrete or ground is negligible, and, having once been exhausted, the metal remains unharmed and protected.

The writer has seen many cases where immersion in standing water has been a matter of years, and in every case the effect upon the metal has been no greater than if it had stood for the same length of time in linseed oil. In one case bolts on the inside of cast-iron cylinders, filled with concrete, were exposed to the salt water in the Harlem River for more than 30 years, and when removed were found to be without rust. In another case a pipe was immersed for ten years in an artesian well, the water in which had not been pumped for 10 or 15 years, and no corrosion of this inside pipe had taken place, the scale was still as fresh as when the pipe was new, and the tool marks of the pipe-coupling apparatus were still perfectly fresh.

Similar results came under the writer's observation in reference to the condition of rods and nails found in wooden foundations where the surrounding material was impervious to air, and in one case which came under his observation, at the time of the removal of the old elevated railway columns in Greenwich Street, New York City, prior to making way for the new structure in 1878, the bottom part of these columns and the bolts in the masonry were found intact, the corrosion gradually increasing until near the surface, where the material was almost entirely destroyed by rust. The experience with both wood and iron, where the renewal of the oxygen in the surrounding water was prevented, has been uniformly that of finding the material perfectly preserved, so that, in the writer's practice, he does not hesitate to advise the use of either material under conditions where a fresh supply of oxygen is excluded. The casing of concrete, in his belief, is an absolute protection against any oxygen penetrating to the surrounding water, and the uniform practice in foundation work in New York City, where both materials are used in combination, is to pay no attention to water-proofing as a preservation, but depend on the concrete to preserve the iron, which it does in the manner stated. There are exceptions to this, of course, but, generally speaking, where the water-proofing is put underneath the steel, it is for reasons connected with the water-proofing itself, more than from any intention to protect the steel in that way. As a matter of fact, water in one form or another is always a possibility, but conditions can be insured which will prevent its being changed, which is the great desideratum.

In answering the third question, it is the writer's belief that concrete should always be made so wet that it will not permit of ramming, but that, after the concrete has been put in place, a certain amount of spading, or "packing back," in the case of the form, so as to give a smooth finish, is all that is necessary in order to produce the most compact and durable concrete. As to rapid desiccation, there is no doubt that if concrete is dried out, or has not had sufficient water to permit of the chemical action or "set" being a finished chemical action, the concrete will be poor, or even worthless. It is not likely to occur, however, under most conditions, even where fresh concrete is allowed to set in the sun, but it has come under the writer's observation many times, in placing concrete under compressed air, that the air which escapes through the concrete in passing out of the air chamber of a caisson is most likely to create veins through the concrete from which the water evaporates before the concrete has had an opportunity to set, leaving that part of the concrete in a condition which is changed very little from that of the dry materials before the concrete was mixed.

In specifications, the writer would advise the entire elimination of the requirement for ramming in beds, and that the concrete should have sufficient water to enable it to puddle itself, with such handling and manipulation as are always incidental to placing it, the only exception being arch work and form work, where ramming may be necessary in order to drive the concrete into places which otherwise it might not fill properly; the ramming in this case being for the purpose of filling the mold, not for compacting the material. As to conditions where the rapid desiccation might threaten it, this should be provided against wherever possible. There is no doubt that wherever this occurs the quality of the concrete is injured and sometimes destroyed.

A UNIQUE VOLCANIC DISASTER was recently reported in press dispatches from Valparaiso, Chile. A volcano appeared in La Union district of the province of Valdiva; the course of the Papasuin River was obstructed by a large stone dam and a lake formed which filled the valley to the crater. The water began to boil, and, continuing to rise, finally swept away the natural dam and flooded the country below, causing many deaths.

TABLES I. TO III.—OPERATIONS DURING 1906 OF THE SEWAGE PURIFICATION WORKS OF THE BIRMINGHAM, TAME AND REA DISTRICT, ENGLAND, TOGETHER WITH DESCRIPTIONS OF THE VARIOUS PERCOLATING FILTER BEDS.

TABLE I.—DETAILS AND COST OF TREATMENT.*

Bed.	1 Date when Bed brought into Use.	2 Volume treated during Year 1906.	3 Rate per Square Yard per day whilst Working.	4 Proportion of Time Bed was Working, Resting and Idle, due to Cleaning Clusters, work on Pipe connections, Repairs, &c. (Yearly taken as 8,766 Hours.) Working.	Idle. Resting and Aerating.	Distributor out of Order.	General Causes.	5 Mechanical Efficiency of Bed working as regard to Degree of Purification Calculated on 100 Gallons per Square yard per Day for 365 days per Year.	6 Capital Cost of Beds including Inlet and Subsidiary Works.	7 Cost of Treatment per 1,000,000 Gallons, including Cost of Silt and Separating Tanks and all Appurtenances. Capital Cost.	Working Cost.	Total Cost.	Remarks.
		Gallons.	Gallons.					For year.	£	£ s. d.	s. d.	£ s. d.	
A	August, 1902	24,619,315	109·9	0·693	0·062	0·176	0·069	43	2,148	3 3 4	16 1	4 0 5	
B	May, 1904	41,967,213	112·7	0·676	...	0·081	0·043	57	1,730	2 1 2	15 0	2 16 2	
C	February, 1904	41,909,171	154·6	0·621	0·021	0·237	0·071	56	2,784	3 5 7	12 3	3 17 9	
D	October, 1904	50,983,617	167·4	0·640	...	0·121	0·039	53	2,481	2 1 4	11 6	2 12 10	
E	April, 1904	137,389,845	169·3	0·935	0·025	...	0·040	92	3,542	1 5 9	12 10	1 18 7	
No. 4	January, 1906	226,940,340	144·0	0·956	...	...	0·044	79	7,084	1 9 11	7 3	1 17 2	
No. 5 (Days 1-6)	September, 1906	216,216,347	160·4	0·944	0·017	...	0·039	90	6,072	1 8 1	8 0*	1 16 1	* The cost of labour is taken over the whole bed.
No. 5 (Day 7)	May, 1906	11,012,306	139·1	0·526	0·422	...	0·052	54	1,112	3 7 5		2 15 5	
No. 6	June, 1905	226,218,438	160·6	0·932	0·029	...	0·039	87	7,084	1 7 4	8 4	1 15 8	
No. 7	May, 1905	205,987,358	163·8	0·929	0·031	...	0·040	89	7,084	1 6 8	8 0	1 14 8	
No. 8	October, 1904	201,978,793	168·3	0·894	0·068	...	0·038	88	7,084	1 7 0	8 4	1 15 4	

*The Imperial gallons used in the table equal 1.2 U. S. gals. A daily filtration rate (see Column 3) of 100 Imp. gals. per sq. yd. is approximately the same as 580,000 U. S. gals. per acre, but it should be noted that the rates given are "whilst working" and that the filters showing the lowest rates were out of service a large part of the time, thus materially lowering the actual working rate, year in and out. £1 = $4.87; 1s. = 24.3 cts.; 1d. = 2 cts. To convert unit cost from Imperial to U. S. gals., deduct one-sixth.

TBLE II.—ANALYSES OF AVERAGE WEEKLY SAMPLES COLLECTED EVERY HALF-HOUR OVER 24 HOURS DURING THE YEAR 1906.

(Parts per 100,000.)

Bed.	Oxygen absorbed in four hours: Crude Sewage.	Crude with Septic Liquor.	Effluent from Beds.	Effluent from Separating Tanks.	Per-centage of Purification—Crude with Liquor—Effluent from Beds.	Per-centage of Purification—Crude with Liquor—Effluent from Separating Tanks.	Per-centage of Purification—Crude Sewage—Effluent from Separating Tanks.	Albuminoid Ammonia: Crude Sewage.	Crude with Septic Liquor.	Effluent from Beds.	Effluent from Separating Tanks.	Per-centage of Purification—Crude with Liquor—Effluent from Beds.	Per-centage of Purification—Crude with Liquor—Effluent from Separating Tanks.	Per-centage of Purification—Crude Sewage—Effluent from Separating Tanks.	Nitrates and Nitrites as Nitrogen: Effluent from Beds.	Effluent from Separating Tanks.	Suspended Matter: Crude Sewage.	Crude with Septic Liquor.	Mix Tank Effluent.	Effluent from Beds.	Effluent from Separating Tank.
	January to September, 1906.*																				
A			1·660		29·3					·203		34·2			2·404	—					
B			3·480	2·041	30·4	22·5	22·7			·403	·239	29·0	21·4	24·9	1·735	—				6·17	1·7
C			2·784		34·3					·274		19·6			2·208	—					
D			2·666		32·0					·270		21·3			2·759	—					
E			3·016	—	32·0	—	—			·270	—	21·1	—	—	2·089	—					
4	27·068	17·748	2·231	—	31·5	—	—	1·582	1·283	·288	—	22·7	—	—	1·944	—	47·0	29·1	6·1		
5 (Days 1-6)			2·231	—	31·3	—	—			·287	—	21·4	—	—	1·221	—					
5 (Day 7)			2·933	—	34·1	—	—			·295	—	21·0	—	—	1·415	—					
6			2·478	—	30·4	—	—			·285	—	22·7	—	—	1·653	—					
7			2·657	—	29·4	—	—			·311	—	25·0	—	—	1·665	—					
8			2·226	—	30·1	—	—			·291	—	20·0	—	—	1·491	—					
	October to December, 1906.																				
All the above combined	26·627	14·458	2·675	2·013	32·2	22·0	22·4	1·643	1·119	·245	·205	20·0	21·7	27·0	2·049	1·629	47·0	32·1	5/6	7·0	1/2

*In September, 1906, the Separating Tanks were completed, and from October to December, 1906, the effluents from the above beds were collected in a common or pick-up channel and conveyed to the Separating Tanks.
† = elimination of 79.0% of the suspended matter.
‡ = elimination of 70.8% of the suspended matter.
§ = elimination of 86.0% of the suspended matter.
‖ = elimination of 69.0% of the suspended matter.

TABLE III.—DETAILS OF CONSTRUCTION OF PERCOLATING FILTERS, TABLES I. AND II.

No.	From.	Area.	Effective Depth or Bed.	Depths.*	Size.	Medium.	Type of Distributor.	Remarks.
A	Circular (Elevated)	sup. yds. 4,840	ft. in. Originally 7 0 Now 6 6	ft. in. 1 0 0 6 0 6 1 0	inches 2½ 1½ 1 ½	Hard Slag (from old mounds) ...	Originally Mather and Platt's full-propelled Jointless Arm; now fitted with Broken Water with Continuous Holes	The top foot of fine medium was removed during March, 1907, as it had become clogged.
B	Circular (Elevated)	1,100	ft. in. 7 0	1 0 0 6 0 6 1 0	2½ 1½ 1 ½	Gravel	Originally Adams' type of Broken Mill, now Adams' Cranked type of Broken Mill	The original distributor being worn out, was replaced by a modern or rec. Cranked type, in November, 1906.
C	Circular (Elevated)	1,320	7 0	1 0 0 6 0 6 1 0	2½-3 1½ 1 ½	Broken Blue Bricks	Originally Scott Mansfield Power-driven by Oil Motor, now driven by Electric Motor	This distributor was replaced, broken (January to April, 1906) by the oil engine and travelling coil taking fire; and the whole of the wooden being destroyed, it was decided to substitute an electric motor for the oil engine.
D	Circular (Elevated)	1,170	7 0	1 0 0 6 0 6 1 0	2½ 1½ 1 ½	Hartshill Quartzite	Cardy Whitaker Compact Masonry Basket, of the Broken Mill type	The centre and bulkhead of the distributor gave way, and was replaced by another, in December, 1906.
E	Rectangular (Below ground level)	2,331	6 0	3 0 0 2 0 0 1 0 0	0-2 1½ 2½-3	Diorite ... ... Gas Works Ashes and Clinkers... Round Gravel	Fixed Spray Jets	The bed was originally filled with Gas Works ashes, but the medium was 2 inches, and this was made up with gravel, in October, 1905.
No. 4	Rectangular (Elevated)	4,800	6 0	4 0 0 1 0 0 1 0	2½ 1½ 1 ½	Hartshill Quartzite	Fixed Spray Jets	
No. 5 (Days 1-6)	Rectangular (Elevated)	4,177	5 3	1 0 0 1 0 0 1 0	1½-2½ 1½-2 1½-2½	Craft Granite	Fixed Spray Jets	
No. 5 (Day 7)	Rectangular (Elevated)	933	5 5	1 0 0 1 0 0 1 0	1½-2½ 1½-2 1½-2½	Craft Granite	Fixed Spray Jets	The top foot of medium was removed in November, 1906, and a portion removed, screened, and replaced; the remainder of the area was filled with 1½ Hartshill Quartzite.
No. 6	Rectangular (Elevated)	4,800	6 0	4 0 0 1 0 0	2½ 1½-¾	Hartshill Quartzite	Fixed Spray Jets	* In reading the column showing depth of medium, the figure 4ft 0in gives applies to the bottom layer of the bed. The next figure applies to the superimposed layer, and so on to the top.
No. 7	Rectangular (Elevated)	4,800	6 0	3 0 1 0 1 0 1 0	2½ 1½ 1 ½-¾	Broken Blue Bricks and Slag ...	Fixed Spray Jets	N.B.—The beds are generally constructed with an impervious floor of concrete, on which are ventilating flues of tiles to lead to the outside air, and a system of underdrains. The bed and allowing the suspended matter to pass freely to the effluent. The medium is kept in place laterally by a retaining wall of dry granite rubble. In Bed G the wall is of concrete of enough width of dry granite rubble. In Bed G the wall is of brickwork, to support the roof on which the distributor travels, the weight on the driving wheel being some 12½ tons.
No. 8	Rectangular (Elevated)	4,800	6 0	3 0 1 0 1 0 1 0	2½-3 1½ 1 ½-¾	1 Day, 5in. Tiles; 5 Days, 12in. Slag Broken Blue Bricks ... ... Hartshill Quartzite	Fixed Spray Jets	

SEWAGE DISPOSAL BY BIOLOGICAL PROCESSES, BASED ON EXPERIENCE AT BIRMINGHAM, ENGLAND.*

By JOHN DUNCAN WATSON,† M. Inst. C. E.

No matter by what method tank-liquor is prepared for oxidation and nitrification on a biological filter, it is desirable that it should be rendered as free from suspended matter as possible. It is possible to reduce the suspended solids in septic liquor from 29.1 to 6.1 parts per 100,000 for the sum of 2s. per [Imp.] 1,000,000 gals. treated [about 40 cts. per 1,000,000 U. S. gals.].

The tank capable of effecting the above result had the Dortmund tank for its prototype, but it is essentially different, both as regards principle of construction and form.

The Birmingham tank is pyramidal in shape, with vertical walls rising to the surface in the form of a square. The sewage is made to enter the tank by a submerged pipe, the downward velocity being 1 to 2 ft. per sec. As it emerges from the mouth of the pipe, it spreads out laterally and ascends to the square portion of the tank at a gradually decreasing velocity, the average velocity throughout being 7 ft. per hour. As this velocity approximates to the falling velocity of the particles in suspension, the tendency is for the latter to separate out and collect in that region of the tank between the mouth of the inflow pipe and the apex or bottom of the pyramid. The sludge-pipe terminates in a sump at the bottom, and whenever the pipe is opened by operating the sluice-valve, the sewage affluent ceases to ascend, or it may even become a downward flow precipitating the suspended matter towards the mouth of the sludge-pipe. The sludge or irreducible residuum of the septic process in this tank amounts to 1.027 [long] tons of dry solid matter per 1,000,000 [Imp.] gals. treated, and may be removed and buried for 8d. per 1,000,000 gals., a figure that includes sludge main and labor, but excludes rent of land [1,918 lbs. or 0.959 short ton per 1,000,000 U. S. gals., at a cost of about 14½ cts. per 1,000,000 U. S. gals.]. The cost of an installation of the tanks of a sufficient capacity to effect the necessary reduction of suspended matter amounts to £520 [$2,530] per acre of bed supplied.

A biological filter should be constructed, whenever possible, on the percolation principle; it should rest on a concrete floor, laid with an inclination towards an effluent-channel. Before the surface hardens it is advisable to lay thereon an aerating tile or false floor capable of sustaining the medium. The chief purpose of the aerating tile is to allow the free exit from the bed of all matter in suspension, whether due to disintegration or imperfect washing of medium, and to admit of the natural evacuations of the bed itself, such as colloidal matter, hydrated oxide of iron, sand, living and dead bodies of organisms, etc.; but the aerating floor also—as it name implies—provides for a free passage of air from end to end of the bed.

A percolation bed should be a permanent structure that requires no renewal, and little or no displacement of medium for cleansing purposes, and this can be obtained only by the employment of good rock or other equally durable material. The qualities next in desirability are roughness of surface, and pieces that approximate to cubes, so to prevent the particles from uniting too closely. Observe those conditions, and almost any medium will answer the purpose of providing a habitat for the bacteria. The accompanying tables show that no merit attaches to medium substance per se, and the beds which I am now constructing contain various kinds of stone (including gravel) and hard slag from different places, mixed together indiscriminately.

It must be admitted that the smaller the medium the more perfect the effluent, depth for depth; but there are other and more important considerations than to obtain a perfect effluent. A perfect effluent is not an ideal one; the ideal is to obtain by natural means an effluent which will not putrefy, and which will continue to improve when it is discharged into a stream; this, when a strong sewage has to be purified, can be done for little more than half the cost by adopting large instead of small medium. Compare Bay 7 with Bay 6 of bed No. 5 [see tables], and it will be seen that Bay 7 (small) was at work for only one-half of its time, whereas Bay 6 was at work 94% of the full time. The cost of purifying 1,000,000 [Imp.] gals. was £3 7s. 3d. against £1 12s. 8d. in favor of Bay 6 [$13.60 against $7.95 per 1,000,000 U. S. gals.].

No doubt the purification obtained was greater in the case of Bay 7, but what of that when both effluents were non-putrescent?

It cannot be too often reiterated that what may be a suitable medium for one sewage may be quite unsuitable for another. The character of the effluent desired, the depth of the percolation bed, the quantity of sewage to be dealt with, the periods of rest necessary, and the facilities for removing suspended solids, all have a direct and reciprocal bearing on the selection of the most suitable size for media.

One of the most important questions to consider is the best way to distribute sewage over the surface of a bed, and it will probably be admitted that the ideal to be aimed at is an imitation of rainfall. The fixed spray jet breaks up the liquid into fine particles better than any other method hitherto adopted, but it fails to distribute an equal quantity over the surface. In this respect it is inferior to a power-driven distributor, whether it rotates round a circular bed or travels up and down a rectangular one; on the other hand, it is much cheaper, e. g., spray jets cost (initial outlay) £500 [$2,500] per acre against anything between £1,000 and £4,000 [$5,000 to $20,000] required to install moving distributors, and reference to column 4 [Table I.] will show how much time may be wasted owing to the repairs required by a mechanical apparatus. Now if it could be shown that the moving distributors were instrumental in producing better results, I should be the last to disparage the use of the traveling distributor on large works; but it cannot. Compare the results from Bed D, which is served by a Candy distributor, with fixed spray jets on Bed 6. In both cases the medium is nearly similar in size, the only difference being that Bed D is 7 ft. deep, and Bed 6, 6 ft. deep. The results show a purification of 83.6 in the case of Bed D, against 80.4 in the case of Bed No. 6, both non-putrescent effluents.

For a considerable time I have been suspicious of crystalline effluents, fearing that they would some day result in serious chokage in the bed itself. I have, therefore, encouraged effluents that contained as much or more suspended matter than was present in the sewage when applied to the surface, and as this represented from 7 to 8 parts per 100,000 of dry solid matter, it became necessary to arrest the solids before discharging them into the river. This was done by the Birmingham separator, constructed as already described. The cost is 1s. 4½d. per 1,000,000 [Imp.] treated [28 cts. per 1,000,000 U. S. gals.]; pumping silt and digging it into land, costs 6d. per 1,000,000 gals. [10 cts. per 1,000,000 U. S. gals.].

The accompanying tables contain facts culled from weekly reports prepared for my own information and guidance; in them ample justification will be found for inculcating caution in estimating the amount of strong sewage which an acre-bed 6 ft. in depth is capable of purifying. On an installation of 20 acres of such beds at Birmingham, not more than 15,000,000 [Imp. or 18,000,000 U. S.] gals. of dry-weather flow can be efficiently purified; with an occasional augmentation of a like quantity for a very short period. Again, the tables show that the adoption of fine medium, although capable of producing a slightly better effluent than large medium, is too costly to become popular; and lastly, the fixed spray jet for large works has not, so far, been seriously rivaled by the traveling distributor.

*Slightly condensed from notes submitted June 21, 1907, to the Engineering Conference, auspices of the Institution of Civil Engineers, London; Section VI., Water-Works, Sewerage and Gas Works.

[The sewage of Birmingham is treated, successively, by settling, septic and separating tanks, followed by percolating filters.—Ed.]

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A NEW METHOD FOR DETERMINING AZIMUTH.

By E. H. McALISTER.*

The method of determining azimuth outlined below is believed to possess certain advantages on the score of simplicity, in those cases where only a moderate degree of precision is sought. The especial merit of the method is that it requires no knowledge of the time or latitude, either for the observation or for the subsequent calculation. While a watch is used in the observation, its sole purpose is to measure an interval of a few minutes, and the watch may as well be wrong by any amount as to be right.

The method involves observations on Polaris and on one other star not near the pole, which for convenience may be called the "time star." The distinctive feature of the method, and the only one for which any novelty can be claimed, is that the interval between the observation on the time star and that on Polaris is made such that the hour angle of Polaris is either the same as that of the time star or different from it by 12 hours, but it is quite unnecessary to know what the hour angle is. In order that the interval between observations may not be inconveniently long, the time star selected should have a right ascension either a few minutes less than that of Polaris, or a few minutes less than that of Polaris increased by 12 hours.

For this purpose, a very excellent star is Spica, which is available in the early evening from about the first of April until August. At other seasons, other stars would have to be selected, or else the observations would have to be taken late in the evening or early in the morning, before sunrise. To avoid needless complication, the method will be described on the assumption that Spica is used as time star, in which case the brief table appended will obviate the necessity for an Ephemeris during the period covered by the table.

For the benefit of those who wish a demonstration of the theory on which this method is based, such a demonstration is appended to this article. It should be noted, however, that though the theory is rather long and involved, the practical use of the method is very simple when the tabulated values of the intervals and log K are given.

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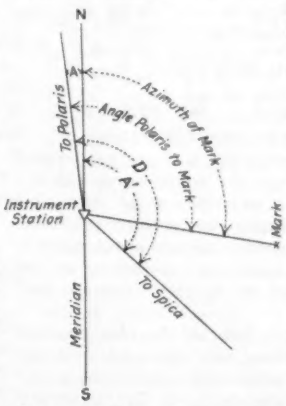
THE METHOD OF DETERMINATION.

The observations are supposed to be made with a "complete" engineer's transit, in good adjustment, and a common watch, which is running at about the right rate, but which may be set at random. As the observations will generally be taken after dark, provision must be made for illuminating the cross-wires and the verniers and the azimuth mark. The program of observation and computation is as follows: (See accompanying figure.)

The transit having been set up and leveled over the station from which an azimuth is desired, point the telescope on the mark, and read the horizontal circle. Leave the lower motion clamped, and use the upper motion during the rest of the observation. Point on Spica, and note the instant by the watch when the star crosses the intersection of the wires. Read the horizontal and vertical circles. Turn to Polaris, and at the expiration of the tabulated interval set the intersection of the wires on the star. Read the horizontal and vertical circles. This completes a single observation. Take as many more as desired, half of them with telescope reversed, if the transit has a complete vertical circle.



Determination of Azimuth by Short Method.

For the computation, obtain by subtraction the horizontal angle between the mark and Polaris, and also the horizontal angle between Polaris and Spica, calling the latter angle D. Correct the altitude of Spica for refraction, and call it h'; likewise correct the altitude of Polaris, and call it h. Take log K by interpolation from Table I., and compute

$$m = K \cos h' \sec h,$$
$$\sin A_1 = m \sin D,$$
$$\sin A = m \sin (D - A_1).$$

The computed A will be the azimuth of Polaris from the north point, and Polaris is on the opposite side of the meridian from Spica. (A rare exception will be noted below.) With the computed azimuth of Polaris and the angle between Polaris and the mark, the azimuth of the mark will be found as in any other method, by addition or subtraction, according to the relative positions of Polaris and the mark with respect to the meridian.

Table I. contains the intervals between the observations on Spica and Polaris and the values of log K (increased by 10), at the dates noted. For intermediate dates, a rough interpolation is sufficient.

TABLE I.
CONSTANTS USED IN AZIMUTH DETERMINATION.

Date.	Interval		Log K.	Diff. for 1 day.
1907.				
April 1	4m.	25s.	8.32478	3.3
" 15	4	25	524	2.9
May 1	4	30	571	2.5
" 15	4	37	606	1.9
June 1	4	49	639	1.1
" 15	5	02	655	0.4
July 1	5	19	661	0.5
" 15	5	33	654	1.2
Aug. 1	5	51	8.32633	

The exception noted above, regarding the relative position of Spica and Polaris with respect to the meridian, which is very rarely found in practice and is only noted to make the theory complete, occurs when Spica is just past the meridian, but not past by the amount of the tabulated interval. Rules might be formulated for this case, but it is better to obey the single precept, not to observe when the stars are very near the meridian (D nearly 180°), unless several observations are taken, in which case the varying values of A will clear up any doubt as to whether Polaris was east or west of the meridian.

Table II., which is a record of a single observation and computation, will serve to illustrate the method.

TABLE II.

RECORD OF DETERMINATION OF AZIMUTH.

Azimuth, Station M to Station P. March 30, 1907. (Interval, 4m. 25s.)

	Hor. Circle.		Vert. Circle.	
On Mark	151°	18.'1		
On Spica (East)	180	46	20°	46'
On Polaris	49	40.2	43	15

Polaris to Mark	101°	37'.9	h = 43°	14'
	D 131°	6'	h' = 20°	43'
Log K	8.32471		A_1	1°11'
" cos h'	9.97097		D—A_1	129°55'
" sec h	0.13753	Log sin	(D—A_1)	9.88478
			Log m	8.43321
" m	8.43321			
" sin D.....	9.87712		" sin A	8.31799
				A 1° 11.'3
" sin A_1	8.31033			
∠ Polaris to Mark		101°	37'.9	
		A 1	11.3	
Azi. of Mark		100°	26'.6 E. of N.	

REMARKS AND SUGGESTIONS.

No other method with which I am acquainted will give anything like the same degree of accuracy with so little expenditure of time and labor, when the latitude and correct time are both unknown. The only astronomical knowledge required in the practical application of the method is the ability to identify Polaris and Spica.

The preceding description of the observations and computation is essentially complete, and the experienced observer will require no further explanation. To the inexperienced, the following remarks and suggestions will be helpful.

If the observer is able to identify Polaris and the Great Bear, or Big Dipper, he can find Spica as follows: Imagine a line drawn from Polaris to Mizar, the star at the crook in the handle of the Big Dipper, next to the outermost star in the handle; then produce the line on through Mizar and it will pass nearly through Spica, which is about twice as far from Mizar as Mizar is from Polaris. Spica is considerably brighter than Polaris, though when near the horizon it may not appear so. In the latter part of May, Spica will be nearly south in the early evening.

In this method, as in all good azimuth methods, the principal source of error will lie in the measured angle between Polaris and the mark, other errors of observation having but slight effect on the result. The most particular parts of the observation are therefore the pointings and readings of the horizontal circle on the mark and on Polaris, and especial care should be given to these, making the pointings deliberately, reading both verniers carefully and estimating fractions of a minute if practicable (recording the mean of the two verniers), and keeping the plate levels well centered at every pointing on Polaris. The altitudes and the horizontal circle reading on Spica are less important, and one vernier reading to the nearest minute will be sufficient, unless there is considerable discrepancy between the verniers.

No great care is necessary in the interpolation for log K, or for the intervals. In fact an error of five seconds in the interval (made either in a rough interpolation or in the observation) will not affect the result by more than about 2 seconds of arc at the most, if the observer is within the limits of the United States, and an error of 6 units in the last figure of log K will cause an error of less than one second of arc in the computed azimuth. It thus appears that the observer may note the time himself, without the aid of an assistant, holding the light in one hand and holding the watch and manipulating the tangent screw with the other. In this way he can catch the beginning and the end of the interval within one or two seconds, which is amply close. These remarks are not made to encourage carelessness in any part of the work, but simply to point out in what respects an excess of care will have no beneficial effect.

In the use of any azimuth method, it is not wise to rely on a single result. In the practice of this method, when several observations are taken, they should be made in pairs, the two observations composing each pair being made one with telescope direct and the other with telescope reversed (if the vertical circle is complete). The process of computation for any pair will then proceed as for a single observation, but using the mean of the circle readings in each case. The result from a pair will be sensibly free from small errors of adjustment in the transit.

Any possible confusion in the horizontal angles will usually be avoided by setting the horizontal circle at the start so that the vernier will read in the neighborhood of 180° when the telescope is pointed at Polaris. The point to be attained is that the zero shall not intervene between two readings of which the difference must be taken. When this has inadvertently happened, the observer will have to use his common sense in getting the correct angle from the observed readings.

If the observer should find himself without a refraction table, he may use the simple rule that the refraction in minutes equals 0.95 multiplied by the cotangent of the altitude. In connection with this method, the refraction should be estimated to the nearest minute only—fractions of a minute are quite superfluous. Refraction tables arranged for the solar attachment or solar compass are not to be used in this connection.

When observing on Spica, do not try to set the intersection of wires on the star. Instead, after bringing the star within the field of view, set the vertical wire somewhat ahead of the star and clamp both circles; then with the tangent to telescope keep the horizontal wire on the star until the star crosses the vertical wire at the intersection. "If at first you don't succeed, try again." In observing Polaris, however, proceed as follows: After the star has been brought into the field of view, the assistant should call out "ready" a few seconds before the expiration of the interval; the observer should then set the intersection of wires squarely on the star, using the upper tangent and tangent to telescope, and keep it so, turning the screws alternately until the assistant calls "time" at the expiration of the interval. It is far more important to have the vertical wire exactly on the star than the horizontal, for reasons already mentioned, but the motion of Polaris is so slow that no difficulty will be found in making both bisections simultaneously.

Since the observations can usually be made as soon as it is dark enough to see the stars, I have frequently set up the transit shortly before dark and made pointings on a distant church spire or other mark, to avoid the trouble of fixing up an artificially lighted mark. Then relying on the stability of the instrument, the remainder of the observation is made as soon as the stars are visible. My experience justifies this expedient, but I do not recommend it, as there is no way of checking the results by a subsequent pointing on the mark; so that any error in it enters all the results with the same sign and is not eliminated in the mean.

A rough sketch made in the note-book, showing the relative positions of the mark and Polaris with respect to the meridian, will avoid any subsequent confusion; but if, as tacitly assumed in all that precedes, the horizontal circle is figured continuously from 0° to 360°, the circle readings will themselves indicate the relative positions, in connection with the precept that Polaris is on the opposite side of the meridian from Spica.

Regarding the accuracy attainable by the method proposed, I may say that in devising the method I had in mind particularly those cases where an accuracy of about one minute is sufficient. Experience with the method indicates that when four pairs of observations are taken, the wildest result from any pair will differ about one-quarter of a minute from the mean, while the mean itself will probably be correct within a few seconds. As a fair sample, four pairs taken May 5, 1906, gave the results (omitting degrees): 34'.9, 34'.8, 35'.2, 34'.9. The beginner should not be discouraged if his first attempts yield results much more discordant than these. Practice and careful attention to the important parts of the observation will enable him to get equally good results. In the work of students at the University of Oregon, the total range rarely exceeds one minute, and in no instance did the total range exceed two minutes.

The observation furnishes data for the computation of time and latitude, but as the method is primarily an azimuth method, the process of computing the time and latitude will not be discussed.

DERIVATION OF FORMULAS.

In deriving the formulas given in the above article, the discussion is general, and does not confine itself to the single case of Spica as time star. The analysis is somewhat lengthy, but is not difficult. The reader is supposed to have in mind the general features of the method as outlined previously, and to have an elementary acquaintance with Spherical Astronomy. The following notation will be used:

T = observed watch time at the instant of observation on Polaris.
θ = the (unknown) local sidereal time at the same instant.
$\triangle T$ = correction (unknown) which must be applied to the watch time to reduce it to local sidereal time.
a = right ascension of Polaris
δ = declination of Polaris
h = altitude of Polaris (observed vertical circle reading corrected for refraction)
A = azimuth of Polaris, from the north (to be computed)
t = hour angle of Polaris (unknown)

The same letters with a single accent (prime) denote the same quantities with reference to the time star. From the definition of the symbols,

$$\theta = T + \triangle T \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

and $$\theta' = T' + \triangle T' \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The reader is assumed to be familiar with the two following fundamental equations of spherical astronomy:

$$t = \theta - a \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\cos \delta \sin t = \cos h \sin A \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The first step is to find the proper interval between the observation on Polaris and on the time star, so that the hour angles will either be the same or differ by 12 hours. In accordance with equations (3) and (1),

$$t = T + \triangle T - a$$
$$t' = T' + \triangle T' - a'$$

Subtracting the second from the first,

$$t - t' = T - T' - (a - a') + \triangle T - \triangle T'.$$

The difference between $\triangle T$ and $\triangle T'$ depends solely on the rate of the watch and the length of the interval; or

$$\triangle T - \triangle T' = r \ (T - T').$$

in which r is the rate of the watch, positive when losing. The equation just preceding then becomes

$$t - t' = T - T' - (a - a') + r \ (T - T') \ldots\ldots (5)$$

If the watch is running at about the right rate for mean solar time, its rate on sidereal time will be approximately + 9.8 seconds per hour. If the hour angles are to be made equal, the right hand member of (5) must reduce to zero; or

$$T - T' = a - a' - r \ (T - T').$$

Thus, the interval is equal to the difference in right ascensions diminished by a small correction for the rate of the watch. In computing this small correction, $a - a'$ may be substituted for $T - T'$ without sensible error when the interval is not large. (If the watch were running exactly at mean time speed, we should have 9.8565 $(T - T') = 9.8296 \ (a - a')$, but for the purpose in hand, either of these rates may be taken at 9.8 seconds per hour, or practically one second for each six minutes difference in right ascen-

sion). Calling the correction for rate C, and denoting the interval $T - T'$ by I, we have

$$I = T - T' = a - a' - C \ldots\ldots\ldots\ldots (6)$$

In a similar manner, when the hour angles are to be made different by 12 hours, the right hand member of (5) is equated to 12^h, and we have

$$I = 12^h + a - a' - C \ldots\ldots\ldots\ldots (7)$$

We can make the interval as short or as long as we please by selecting time stars of suitable right ascension with respect to that of Polaris. In order to avoid too long a wait between observations, the interval should be reasonably short, and since the last star observed must be caught on both wires at a predetermined instant, namely, the expiration of the interval, it is better in practice that Polaris come last, on account of its slow motion. Hence T should be greater (that is, later) than T', and consequently in (6) a' should be less than a by a few minutes, and in (7) a' should be a few minutes less than $12^h + a$. In either case, C is to be computed mentally at the rate of one second for each six minutes in the interval, and the nearest second is more than amply close, for this purpose. For instance, if the interval is about 20 minutes, call C three seconds. The right ascensions, as well as the declinations, to be used later, are to be taken from the American Ephemeris or a similar work. The time star should, of course, be a rapidly moving star, and hence not near the pole. The intervals can be computed and tabulated in advance along with log K (see below).

The next step is to find an expression for the azimuth of Polaris, in terms of known quantities. The observation having been taken as described in a preceding paragraph, and the latitude and local time being unknown, the known quantities are the declinations of the two stars, their altitudes, and the difference of their azimuths. In order to avoid confusion in the algebraic signs, the reader may for the moment regard azimuths as measured clockwise continuously around the horizon, though in the practice of this method the azimuth is usually counted both ways from the north point, without regard to sign. Referring to equation (4), we have at the instant of observing Polaris,

$$\cos \delta \sin t = \cos h \sin A,$$

and likewise for the time star,

$$\cos \delta' \sin t' = \cos h' \sin A'.$$

Since the hour angles are either equal or differ by 180°, their sines are numerically equal; also, when the signs of sin t and sin t' are the same or opposite, the signs of sin A and sin A' will be the same or opposite. Dividing the last equation by the preceding, canceling out the equal sines of the hour angles, and solving for sin A, we obtain

$$\sin A = \frac{\cos \delta}{\cos \delta'} \frac{\cos h'}{\cos h} \sin A'.$$

Denoting by D the observed horizontal angle between the time star and Polaris (see figure), $A' = D \pm A$, and hence

$$\sin A = \frac{\cos \delta}{\cos \delta'} \frac{\cos h'}{\cos h} \sin (D \pm A) \ldots\ldots (8)$$

The use of the positive or negative sign depends on the origin chosen and on the direction in which azimuth is measured. If the origin is the south point and azimuths and horizontal angles are measured clockwise, then the azimuth of Polaris will be in the neighborhood of 180° (for moderate latitudes), and the positive sign will be used if the time star is east of the meridian, and the negative sign for time star west. But if azimuth is reckoned both ways from the north point, and the angle D is taken less than 180°, then the positive sign will be used for a time star having nearly the same right ascension as Polaris, and the negative sign for a time star differing nearly 12 hours from Polaris, as Spica. In theoretical discussions, the former method of reckoning azimuths and angles is to be preferred, but for simplicity the final formulae have been arranged in accord with the latter.

The quantity cos δ/cos δ' is known beforehand, and its logarithm may be tabulated; call it K. Then (8) may be written

$$\sin A = K \cos h' \sec h \sin (D \pm A).$$

We now have an equation in which A is the only unknown quantity, but A appears under two different functions. An analytical solution of this equation can be effected by well known trigonometric methods, but this involves some labor and the introduction of an auxiliary angle for easy logarithmic work. The following approximate solution gives practically correct results, and is much shorter and simpler. The angle A (from the north) will always be small for moderate latitudes, say not far north of 60°. Consequently the angle D will be approximately the azimuth of the time star, and sin $(D \pm A)$ will not differ very greatly from sin D, and when this is multiplied by the minute factor K, the error is vastly reduced. Hence, for a first approximation, we may take

$$\sin A_1 = K \cos h' \sec h \sin D,$$

and for a second approximation,

$$\sin A = K \cos h' \sec h \sin (D \pm A_1)$$

The second approximation will give a practically exact value of A. The quantity $K \cos h' \sec h$ is used in both approximations, and it will save a little labor to segregate it; call it m. Finally we have (log K being tabulated),

$$m = K \cos h' \sec h \ldots\ldots\ldots (9)$$

$$\sin A_1 = m \sin D \ldots\ldots\ldots\ldots (10)$$

$$\sin A = m \sin (D \pm A_1) \ldots\ldots\ldots (11)$$

The last step is to compute the azimuth of the mark, which is done as in any other method, namely, by combining the computed azimuth of Polaris with the horizontal angle between Polaris and the mark, as previously directed. Polaris will be on the same side of the meridian as a time star differing little from it in right ascension, and, of course, on the opposite side from a time star differing nearly 12 hours.

SEMI-ANNUAL MEETING OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

The summer or semi-annual meeting of this Society was held at the Pfister Hotel, Milwaukee, Wis., on July 18 and 19, with about one hundred members and guests in attendance. Of the five papers presented, only one received much discussion, and much the same fate met the ten topical subjects for discussion.

THE HEATING AND VENTILATING OF RAILWAY CARS.—This paper, by Mr. E. R. Swan (Cedar Rapids, Ia.), consisted largely of quotations from different writers. Its main purpose was to describe an apparatus invented by the author for the automatic regulation of the air supply to cars. The general system is somewhat similar to that proposed by Dr. C. B. Dudley, of the Pennsylvania R. R. (Engineering News, Sept. 29, 1904), but with the addition of regulating apparatus, and also with the difference that the air is introduced at the top instead of the bottom of the car. With Mr. Swan's proposed system, the fresh air enters a hood above the roof and is led through a pipe to a chamber near the bottom of the car; here it passes over heater pipes and then through a filtering or washing screen, finally entering the car through openings at the ceiling. The foul air is drawn off from the bottom of the car and led to an uptake, being discharged through a funnel or hood above the roof. Both the entrance of fresh air and the withdrawal of foul air are automatically varied with the speed of the car and in accordance with the wind and atmospheric conditions. Apparently the proposed system has never been applied to practical use. The author suggested the removal of the monitor deck roof, as being useless for ventilating purposes. We may note that the new steel passenger and mail cars of the Southern Pacific Ry., as well as its gasoline motor cars, have elliptical or turtle-back roofs. In these cars, roof ventilators are used, with exterior funnel mouths facing in both directions, and interior screens and regulating registers.

AN ISOLATED CENTRAL PLANT FOR PUBLIC SCHOOLS.—In a paper on "Heating and Ventilating a Group of Public Schools," Mr. Samuel R. Lewis (of Chicago), described a power station plant installed at Galesburg, Ill. The three school buildings had been heated with exhaust steam from the electric light and railway power plant, but this system is not economical when (as for these schools) it is only operated for a few hours each day, and for only five days in the week. With the long period of cooling the demand for steam on cold mornings was enormous. To quote from the paper:

> The school district decided to furnish its own steam, power and lights. The basements of the buildings were required for other purposes, so a separate boiler-house was decided upon. The blast steam method of heating and ventilation was adopted. The air is drawn through tempering coils, to the fans, which discharge through heating coils and by-passes to plenum chambers. These chambers are each divided into two horizontal compartments; one containing tempered air at about 60° F.; the other containing heated air at about 130° F. From these chambers single sheet-metal ducts lead to vertical flues which supply the various rooms and departments. The single ducts have double dampers in the connections to the plenum chambers, so that air at varying temperature but constant volume may be admitted. The flues discharge through adjustable diffusers at about two-thirds of the height of the rooms. The ventilating grills are at the floor line on the same side of each room as the inlet openings. The ventilating flues are connected in the attic with sheet metal ducts, leading to ventilators in the roof. They also connect with vertical shafts leading back to the fans, so that the air in the buildings may be rotated. The temperature of the rooms and tempered air plenum chambers is automatically controlled. The dampers in the roof ventilators and return air shafts are controlled from the basement by compressed air. Direct radiation is installed in toilet rooms and corridors, and auxiliary direct radiation is placed in such other rooms as have plumbing apparatus, or which might be used by a small number of persons on holidays, or at night when the fans would not be in operation.

The plant comprises three boilers, aggregating 375 HP., two high-speed automatic engines with cylinders 12 × 14 ins., and two 50 KW. generators. The three fans are designed to furnish 30 cu. ft. of air per occupant per minute, at a pressure not exceeding ½-oz. at the fans. They are driven by two electric motors of 15 HP. and one of 7½ HP. The cubic content of the three buildings is 1,196,698 cu. ft.; air per minute, 86,500 cu. ft.; blast radiation, 7,078 sq. ft.; direct radiation, 7,350 sq. ft.; indirect radiation, 1,200 sq. ft. There are also 900 lights of 16 c. p., and motors of 15 HP. in the manual training department. The total load is about 80 KW., but there is slight possibility of more than half of this capacity being required at any one time, so that the generators are practically in duplicate. The results obtained from this plant are stated as follows:

> The plant has been very satisfactory in operation. The fuel cost for heating, ventilating and lighting the buildings for the season of 1906-1907 has been at the rate of $1.727 per 1,000 cu. ft. There is no connection for power from outside sources, and the above cost includes the lighting and ventilating on many days and evenings when no heat was required, thus involving a higher operating cost than a mere heating equipment would show. An engineman and one fireman have operated the plant. The expense for attendance has been no greater than it would have been had the janitors of each building handled ordinary systems located therein. The expense to the school district has been at least $1,000 per year less than it would have been had the electricity and steam been purchased. The gain in space in the buildings; absence of fire in them; elimination of boilers under school rooms; ability to burn cheap fuel economically; and the absence of dirt and dust, all point to the advantage of a separate power plant under the conditions stated.

A paper on "The Design of a Plenum System of Warm Air Heating for a School or Office Building," by Prof. J. D. Hoffman (Purdue University), dealt with the systems of calculating employed in making such a design, including the following features: The heat loss of the building, coil heating surface, amount of air required, size and power of fan, boiler capacity, sizes of ducts, etc. Mr. Oliver H. Schlemmer (Cincinnati) presented a paper on "Formulas for Pipe Sizes in Hot-Water-Heating."

The preliminary report of the Committee on Hot-Water Heating presented a synoposis of replies to certain inquiries, without any recommendations as to rules, etc. The inquiries related to radiation and cast-iron boilers.

THE COMBINED PRESSURE AND VACUUM SYSTEM OF STEAM HEATING.—This paper, by Mr. Geo. D. Hoffman (New York) aroused more interest than any of the others on the program. The author said:

> About five years ago there was introduced a new system of vacuum steam heating, the vacuum being created by the condensation of steam within the apparatus instead of by mechanical means. Since then there has been a strong trend among progressive heating engineers toward this system of combined low pressure and vacuum steam heating in connection with gravity plants.
>
> The term vacuum as used in connection with a steam apparatus signifies that means are employed to relieve the apparatus of air or atmospheric pressure, and by

preventing its return thus create a condition under which steam will circulate at temperatures below 212° F. The two biggest leaks in any apparatus are at the stuffing box of the radiator valves and the venting valves. If the engineer effectually stops these leaks, the rest is easy.

With apparatus that is steam, water and air tight, he can circulate steam throughout the system at temperatures both above and below 212° F., and by thus increasing the temperature range within the apparatus he can meet external weather conditions with an even and equable indoor temperature, and do it with a surprising fuel economy.

The advantages claimed for this system are; a temperature range of from 140° to 240° F., economy in fuel and labor, more equable and comfortable temperatures in the house, and low cost of installation. There was a protracted discussion on this paper, bearing mainly upon the real economy of different systems of heating. There seemed to be no doubt as to the economy due to the use of a vacuum, enabling low steam temperatures to be used. In most buildings, there are certain radiators that are usually kept closed and only opened in very cold weather. The vacuum system enables all radiators to be kept open, giving a better distribution of heat, but without an unnecessarily high temperature.

The program included ten subjects for discussion, but as usual only a few of these called forth any remarks.

Visits were paid to the works of the H. W. Johns-Manville Co., manufacturing pipe covering, and the Johnson Service Co., manufacturing apparatus for the automatic regulation and control of temperature, etc. At both places lunch was served. There was also a visit to the engine works of the Allis-Chalmers Co. The proceedings were closed by a dinner at Whitefish Bay.

RECENT ADVANCES IN ARTIFICIAL LIGHTING.*

INCANDESCENT LAMPS.

During the past few months several new incandescent lamps have been put upon the market in commercially successful forms, whose light-producing efficiency is considerably higher than the forms in use for many years past. Some of these new lamps give three or four times as much light from a given amount of power as the old style carbon lamps.

It seems probable that these new lamps may bring about many radical changes in the electrical industry. That there are at least possibilities in the field every one will admit. If we can get four times the light for a given power we can also get the same light as at present for one-fourth the power. The new advance means, therefore, not only better and more liberal illumination, but an extension of electric lighting into fields where it has been hitherto deemed too expensive.

These changes, however, are likely to be gradual and not sudden. Some of these new styles of lamp do not adapt themselves well to existing systems for the distribution of electricity. On account of the vast amount of costly equipment, now in use in such systems, it seems probable that the attempt will be first made to adapt the new lamps to existing systems. The operating economy of the new electrical illuminants over those in use since 1880 is so great that if the distribution systems and the lamps continue to conflict we may expect the systems to change.

For example, if the tungsten lamp develops, as expected, into a commercial success with an efficiency of one watt per candle power, but requiring a 50-volt distribution service in order to have reasonably low candle power for domestic use, the economy over the ordinary incandescent lamp would create a demand that future alternating current installations should be supplied with 50-volt transformers instead of 100. Moreover, the saving would be large enough to more than pay the interest on the cost of discarding many present domestic installations and arranging new ones suitable for tungsten lamps.

A peculiar feature of the development of the new lamps is immediately beneficial to the central station companies. The lamps are not made as yet in small candle powers for common voltages. The nearest approach to such production is in the 20 c. p., "metallized" and tantalum filament lamps. These are intended by the makers to supplant older carbon filament lamps of smaller candle power, but using about the same energy per lamp. A development of the new lamps in any way that would tend to have an immediate decrease in central station receipts would never be favored by central station people, no matter how strongly it were impressed on them that such an effect would be merely temporary and that the development could only result in an extension of electric lighting which could not fail to be advantageous to them. It seems probable that a few persons will decrease the number of lamps in use with the substitution of higher candle power units. Most consumers, however, will not like the appearance of unfilled sockets or unused lamps in fixtures and will use the same number of lamps as before, contenting themselves with the thought that they are getting more light for equal money.

EFFICIENCY OF A LIGHT.—The efficiency of the common form of carbon filament lamp is only a fraction of one per cent. That is, of all the energy applied ninety-nine and a fraction per cent. goes off as waste heat. This has been the incentive for all the investigation and experimenting of many years back. The present time seems to have brought almost simultaneously the culmination of several distinct efforts. It should be remembered, however, that these practical results are the outcome of years of patient laboratory investigation and experiment.

It is impossible to make a uniform and completely logical definition of the "efficiency" of an illuminant from physical data. Light is, of course, the physiological action of certain radiations of energy. Such effects vary with individuals and with external conditions. Rays close to yellow arouse greater optical sensations than rays at either the violet or red ends of the spectrum. One candle power of red or violet light represents a source actually sending out more radiant energy, other than heat, than one candle power of yellow or green.

In general it may be said that a solid light source is more efficient, that it has less waste heat, the higher its working temperature. The reverse is true of luminescent vapors and gases. This will be taken up in a later article.

SELECTIVE RADIATION.—The efficiency of an incandescent solid body depends on still another phenomenon, though to a lesser degree than on temperature. This is called "selective radiation," and just what is meant by the term is best shown by approaching it in a roundabout way.

At a given temperature, the total energy radiated in all ways (that is as light, as heat and as chemical energy) is greater per unit area for an ideal dead black surface than for any other known surface. In general, it may be said that any substance capable of being raised to a temperature of 1,500° C. or over, radiates less total energy than would the ideal dead black body, at that same temperature. A greater percentage of the energy radiated by the former passes in such wave lengths as cause the sensation of light than in the case of the ideal black body. Therefore any body, other than the ideal black one, is selective in its manner of radiation. It is also obvious that the dead black body is the least efficient light source.

The common carbon filament approaches the dead black body the nearest of any filament made. Hence it is least efficient as a radiator of light, and it was only its valuable mechanical properties that caused its adoption for incandescent lamps.

The new filaments are better than the old carbon filaments for two reasons. First, they can be worked at higher temperatures, which are maintained by a less expenditure of energy. Second, a greater percentage of the total radiant energy exists in such wave lengths as the eye is most sensitive to. This is shown in the comparison of color values given in Table I.

The question naturally arises as to why the old carbon filament cannot be worked at these higher temperatures, since the melting and boiling point of carbon is so remote. It has been demonstrated that the highest temperature at which any filament can be operated with a reasonably economical life does not depend on the melting or boiling point of the substances from which the filament is formed, but upon its vapor tension or liability to gradual evaporation at lower temperatures.

THE METALLIZED CARBON FILAMENT LAMP.—The new form of carbon filament known as "metallized" owes its success as a light source to two properties. The first of these is a greatly lessened tendency toward evaporation of the filament or some content thereof. This consequently gives a much smaller amount of blackening of the interior walls of the bulb and enables the useful life of the lamp to be limited by the time of actual rupture of the filament. This increased vapor tension effect is due probably to an altered chemical composition of the filament itself. As will be shown later, the chemical composition of the filament is changed in two ways.

The second property, more or less related to the first, contributing to its value as an illuminant, is its increased strength, enabling operation at a much higher temperature and a consequent lower power consumption per unit of light furnished.

A glance at an ordinary filament and a "metallized" filament will show that the latter has less of the appearance of a "black body." We may expect then that a portion of its increased efficiency is due to a greater degree of selective radiation.

It should be stated that the term "metallized" is misleading and needs explanation. There is no metal introduced into or upon the filament in this process. The term is used wholly to indicate the changed appearance and different physical properties of the new filament from the older form of a carbon filament. Lamps having metallized filaments are often called "Gem" lamps. The word Gem is a trade name, a contraction of "General Electric Metallized."

Before discussing the improvement wrought by the introduction of this type, it is well to briefly state the actual processes of manufacture, that we may compare the older with the newer.

Up to a certain point both types of filament are made alike. Pure cotton is made into soluble cellulose, carefully heated and settled to remove air bubbles and to insure a proper degree of consistency. This solution is squirted into jars of alcohol by automatic machines and at the same time coiled as a continuous thread in the bottom of the liquid. This gelatinous thread receives a preliminary drying by passing around steel drums properly heated. The threads are redried on proper forms in ovens, and cut into individual lengths. The threads are packed in iron boxes with pulverized peat and subjected to the highest heat obtainable in an oven, without using an electric furnace. The carbonized filaments are measured, selected and assorted before receiving further attention.

From this point, the old and new processes are distinct. The filaments for the old style lamps are next "flashed," or raised to partial incandescence for a short space of time, in a rarified vapor of gasoline or other hydrocarbon.

The filaments for the metallizing process are packed with powdered carbon in an electric tube furnace and subjected to the highest heat possible with this type of furnace. So high is the temperature attained that the carbon tube in which the filaments are packed is so nearly destroyed that it cannot be used a second time.

After this metallizing process, the filaments are "flashed," as were the others, in a rarified atmosphere of hydrocarbon vapor. The carbon deposited on the filament by this portion of the process needs to be itself treated to a term in the tube furnace, after which the filament is reflashed in the gasoline vapor. It is now ready for assembling in the completed lamp. Two filaments are joined in series as shown in Fig. 1.

It is this layer of carbon, deposited on the basic filament and passed through the intense heat of the tube furnace to which the properties

*It is intended to supplement this article by a later one on the new light sources employing luminescent gases and vapors.

of the new filament are largely due, and it has been found that this double metallizing heat, on the core first and later on this layer, is necessary for the desired filament.

It is believed by some persons that there is during the second heating in the tube furnace a

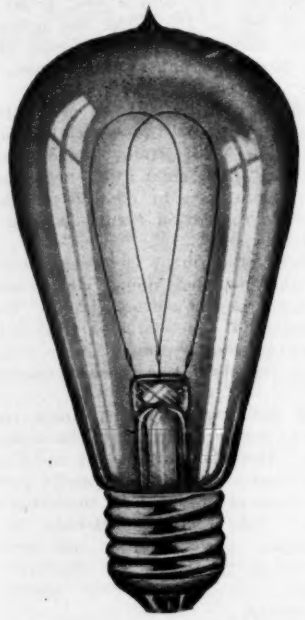


Fig. 1. The "Metallized" Carbon Filament Lamp.

polymerization of the atoms of that carbon which was deposited in the first flashing. The graphitic appearance and peculiar physical properties might be explained by such a theory of a polymeric arrangement of the atoms.

If this "allotropic" form of carbon, as some persons choose to call it, be deposited on such a core as may later be removed at desired stages of the process, most remarkable physical properties are manifested. At one stage, such a little tube could be pressed together, say by a hard blade, and when pressure was removed would spring into its original shape as though made of rubber. At a different stage of the process the tube would behave as one made of lead. These characteristics are foreign to the hitherto known physical properties of carbon.

This form of carbon, contained in the outer portions of the "metallized" filament, was discovered by Dr. W. R. Whitney, Chief of the General Electric Company's Research Laboratory at Schenectady, N. Y. The development of this discovery into the present lamp filament is due to the work of Messrs. J. T. Marshall and J. W. Howell, of the Edison Lamp Works at Harrison, N. J., whose work has covered a period of something over two years.

It was stated at the beginning of the discussion of this filament that the chemical composition is changed in two ways by the metallizing treatment. These two ways are: the removal of the ash content and the reduction or distillation of the last hydrocarbons left by other heatings.

During the "metallizing" process the heat is so intense that the small amount of sodium and potassium ash necessarily contained in the soluble cotton (which amount is about 1% of the weight of the basic filament), is almost entirely eliminated, being more volatile than the amorphous carbon. This loss of about 1% is not all that the basic filament experiences. After the first treatment in the tube furnace, the filaments are actually something like 10% lighter. We need not seek far for an explanation. The cellulose from which the filament is formed is a compound of carbon, hydrogen and oxygen—a hydrocarbon or a group of hydrocarbons. In the ordinary carbonizing process most of the hydrogen and oxygen pass off, leaving amorphous carbon. However, it may be expected that a little of some hydrocarbon compounds are left in the filament. The blackening of the bulb of the old type lamps would indicate a slow distillation of such from the filament.

The physical stability of the metallized filament is so much greater than the ordinary, that the allowable working temperature has been increased from 1,800° C. to 1,950°. For the same candle-power units a filament of smaller cross section is employed in the metallized type than in the ordinary. Thus the basic filament for a 20-c. p. unit of the new type is the same size as that of the basic filament of the old 12-c. p. lamp.

The greatest need for improved efficiency in the old style filaments was in the units of over 20 c. p. Therefore the first applications of the new process have been made for lamps of 20 c. p. and over. To make lamps in the smaller sizes, say of 4, 8, 10, 12, 16 c. p., with a power consumption of 2.5 watts per c. p., would require a filament of such a small cross section as to seem at present unadvisable. Future development may bring some such results; but for the present the 3.1-watt lamp in these sizes mentioned is reasonably economical for a carbon filament and is serviceable.

It would seem, however, that a lamp could be produced in these sizes having the "metallized" filaments but designed to work at the temperature of the usual type and therefore having about the same cross section for a given c. p., or at least a cross section not so small as to be prohibitive. The gain, of course, would be in the longer life and greater freedom from blackening of the bulb. The light would perhaps be a trifle more satisfactory on account of the better inherent regulation of the metallized filament due to its positive temperature coefficient.

The metallized lamps are made in 250, 187, 125, 100 and 50-watt sizes, all having a useful life of about 550 hrs., with a power consumption of 2.5 watts per c. p.

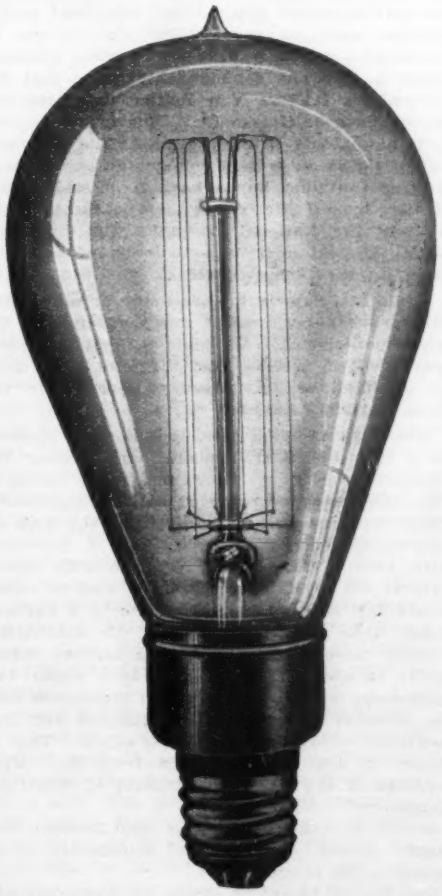


Fig. 2. The American-Made Tungsten 110-Volt. Lamp.

The General Electric Co., of Schenectady, controls the patents on this process, and has licensed numerous independent lamp manufacturers.

The commercial introduction of this type is expected to be on such a scale that in a few years 70 or 80% of all carbon lamps will be included. This form of incandescent lamp, of all the new types, is the one most readily adaptable in small candle power units to present electric distribution service.

THE TUNGSTEN FILAMENT LAMP. — Tungsten has long been classed as one of the rare metals, but it is now found in considerable quantities in many parts of the world. As an alloy of steel, it is already of large commercial importance, and the filament used in an incandescent lamp is so small in actual weight that present sources of tungsten could readily supply all requirements. The high cost of incandescent lamps with tungsten filaments is due not to the cost of the metal but to the great difficulties in making the filament.

Metallic tungsten is brittle, and infusible by ordinary commercial methods. It unites with both carbon and oxygen at high temperatures. The methods of filament manufacture seem numerous, and there may be possible several commercial and competing processes.

Without making a careful investigation, in this country and abroad, it could not be justly stated exactly what the "earliest" process was. At any rate, such information would be of little value in this article and might have the effect of arousing unwarranted controversy. It is interesting, however, to note the patents granted to Alexander de Lodyguine, of Pittsburg, Pa., on Jan. 12, 1897, for claims filed Jan. 4, 1893. The Lodyguine process consists mainly of the deposition of osmium, tungsten or similar metals from chlorine compounds, upon a very minute platinum wire. This process may have a bearing on the latest developments and at least show that all the investigations of metal filaments have not been made abroad.

The earliest process given public attention is that of Dr. Hans Kuzel, of Vienna, Austria. A "colloidal" solution was formed by making an arc between tungsten electrodes, under water. This solution was brought to a proper degree of consistency by evaporation so that it could be squirted into filaments which were dried and heated to a welding temperature. Some Americans who have investigated this process claim the methods to yield results too uncertain and unreliable to be commercially practicable. However, a limited number of Kuzel lamps are being made in Austria and a few are being imported to this country.

In a process developed by Just and Hanaman a fine carbon filament was heated in an atmosphere of hydrogen and tungsten chloride. Under proper conditions, tungsten was deposited on the carbon, the hydrogen acting as the reducing agent. The filaments were next heated to a high temperature in an atmosphere of steam and hydrogen. Here the steam was decomposed and its oxygen united with the carbon of the tungsten carbide, which may have formed when the tungsten was deposited on the filament. Evidently this process was unsuccessful, for on May 28, 1907, a patent was granted to Just and Hanaman on a method of making tungsten filaments. The claim states that experience has shown it to be commercially impossible to use a carbon filament as the base of the above process, as the reactions take place only near the surface and the core remains only very slightly altered. In the new process the base is a filament composed of a mixture of carbon, tungsten oxide or sulphide or some similar compound, and an organic binding material such as collodion, tar, etc. This paste is squirted, dried and carbonized. The carbon gives the structure enough strength to withstand the future treatment, which is similar from this point, to the older process.

There are at least two American processes of making tungsten filaments. One of these has been developed by the Westinghouse Lamp Co., the other is the method of the General Electric Co., and its licensees. The exact stages of the American processes cannot herein be stated. In general it may be said that the tungsten is held suspended in a finely divided state in such a solution as is squirted into filaments. The solution, of course, must contain enough binding material to allow the drying and welding processes to be carried on.

The tungsten filaments exhibit the usual characteristics of pure metals. The electrical conductivity is high, requiring a long filament of small cross section. The temperature-resistance coefficient is positive, and on this account the lamps have considerable inherent regulation. The changes in light production and power consumption are less for given voltage fluctuations than in the case of the older carbon filament lamps.

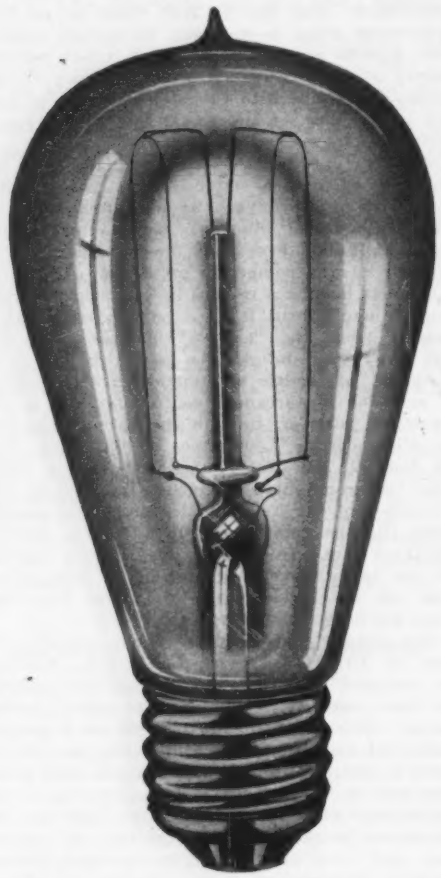


Fig. 3. The American-Made Tungsten Low Voltage Lamp.

The color of the light emitted at proper voltage is near that of acetylene gas used in a good burner. At full incandescence, the filaments are softened, and even with the divided and supported loops the imported lamps must be burned in a vertical position. The American lamp, however, can be used in any position, though such use in places where the lamps are apt to receive any jar increases the liability of filament rupture.

The greatest difficulty at present encountered by all makers is in constructing lamps of reasonably low candle powers for present domestic voltages, that can be safely transported. Stout filaments are now made in small candle powers for current between 2 and 25 volts, and in units from 40 to 100 c. p. for 100 to 125 volt service.

On account of the brittleness of tungsten trouble is found in shipping lamps with the lighter and longer forms of filaments over American railroads. The loss by breakage may rise as high as 50%. A loss of less than 3% is claimed during European transportation, and if this figure is substantiated the continental railroads must handle goods twenty times more carefully than the American! Even by ocean transportation private shipments of tungsten lamps from Germany have had a breakage of 10 to 20%. The low voltage lamps are being tried in electric train lighting, but results are not yet available. It is known simply that they have successfully resisted the vibration of several long trips. Such lamps, of course, can be safely shipped anywhere.

Such fragility is not discouraging for the future of the tungsten lamps when we consider the history of the carbon filament. In the very early carbon lamps trouble was found in making a filament of sufficient durability to mount in the bulb.

The tungsten filament adapts itself to series street lighting systems which are favorably comparable with any other illuminant in economy. This could not be said of the older form of carbon filament series lamps. The tungsten series lamps can be operated for about 1,000 hours life with a power consumption of 1.25 to 1.50 watts per c. p. They are sold in 40 and 60 c. p. units for 4.0, 5.5, 6.6 and 7.5 ampere systems. The list price varies from $1.35 to $1.75, according to amperage and quantity of lamps bought.

At this point, a word may be said respecting the contrast between the business methods of American and European makers of tungsten lamps. The European manufacturers have developed some types which are practical but whose final commercial reliability remains to be determined. It is said that these lamps are being turned out in as large quantities as it is possible to force from the small factories producing them. They are being advertised in this country quite widely. The American makers, on the other hand, are proceeding very cautiously. They feel that a better tungsten filament can be developed and one with less fragility, and they do not consider it wise to advertise so widely that orders will be booked which cannot be quickly filled.

THE TANTALUM FILAMENT LAMP.—Pure tantalum is quite difficult to obtain, and only by an expensive process. The tantalum ores are about as widely distributed as the platinum supply. What formerly was regarded as the pure metal now proves to have been a mixture of pure tantalum and an oxide in varying quantities of the latter. The effect of this oxide was to introduce brittleness, and only of late has it been possible to study the characteristics of the pure metal. It is known to have a tensile strength equal to that of the best steel and a melting point of about 2,300° C. It can be rolled into sheets or drawn into wire, although there is only one commercial process, that developed by Doctors Von Bolton and Feuerlein, of the Siemens-Halske Co. This company controls the patents on the processes. The American patent rights on present commercial processes of making tantalum lamps have been sold jointly to the General Electric Co., of Schenectady, N. Y., and the National Lamp Co., of Cleveland, Ohio. The latter is an association of about 15 lamp manufacturing concerns.

While tantalum lamps are made in the United States by the companies mentioned above, the wire from which the filaments are cut is still imported. It is possible that the pure metal may be produced in this country later under the Siemens-Halske patents.

When the lamp is new, the filament appears as a fine and fairly smooth wire. Later the filament undergoes some structural changes. This effect may be regarded as a crystallization which becomes accentuated by using the lamp on alternating current circuits, and it increases with higher frequencies. By use with direct current the crystals—if the action can be called crystallization—arrange themselves in a uniform order, while by the reversals of the alternating current these crystals as formed arrange themselves irregularly. The appearance under the microscope is such as to give the impression that the filament had repeatedly separated and immediately welded itself together again. This is shown in Fig. 6, reproduced from the "Proceedings of the American Institute of Electrical Engineers."

Welds do take place after the filament has visibly parted, and the joint apparently is as strong as the original wire.

The life of tantalum lamps on direct current is from 800 to 1,400 hours, and on alternating current of 25 cycles is about 600 hours. By increasing the frequency to the common 60 cycles per second the life is reduced to between 250 and 400 hours. These figures were quoted by Dr. Feuerlein while in the United States a few weeks ago, and should be a good average. American tests on early lamps gave a life roughly about 40% shorter. There have been a few exceptional lamps, in the run of common factory tests, which show a performance equal to the average on direct current. This leads to the supposition that there are some qualities of tantalum, not yet understood, which become dominant under obscure conditions. These lamps are being made in this country in two sizes, a 20-c. p. 40-watt unit and a 40-c. p. 80-watt for voltages of 100 to 125. The list prices are 45 and 60 cts., respectively. An average life of the lamp on direct current of 1,000 hours may be expected.

There is a positive change of resistance of about 3% per volt at the working temperature of the filament. The same change in the older carbon lamp was some 6% negatively. As previously mentioned in connection with other lamps, better regulation results with a positive coefficient.

The length of filament is so considerable that it is strung between nickel arms held in a glass spindle, as shown in Fig. 5. This gives a good horizontal but poorer vertical distribution which can be greatly improved by frosted tips and proper reflectors, like those of the holophane type.

With all the newer filament lamps, care must be taken to remove them from the ordinary field of vision. The filaments in all cases are of a smaller diameter for a given candle power unit, a higher temperature, and an increased intrinsic brilliancy. The tendency already is toward larger candle power units, and serious eye trouble may result from their improper and indiscriminate use. They should almost always be well shaded.

THE "HELION" FILAMENT LAMP.—This new filament is the result of the laboratory researches of Prof. H. C. Parker, of Columbia University, and Mr. W. G. Clark, of New York City. While the type of filament developed is not strictly metallic, it has some characteristics which would be expected of true metals. For instance, the filament may be fused together by contact, much like a tantalum filament.

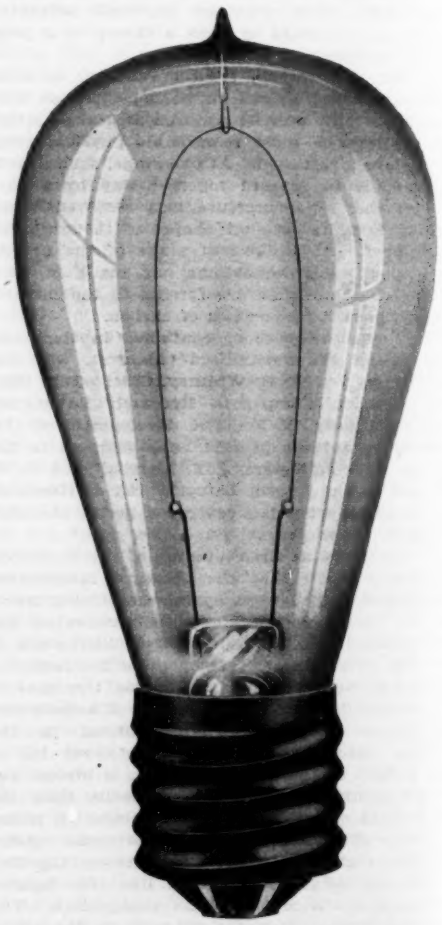


Fig. 4. The American-Made Tungsten Series Incandescent Lamp for Street Lighting.

The Helion filament is composed to a great

extent of silicon, which is at present deposited on a special carbon filament. It will be remembered that in the early days attempts were made to use silicon for lamp filaments, but with no practical results. Professor Parker has stated that he believes that the resultant form of silicon, from the "Helion" process, may be regarded as "allotropic," bearing the same relations to amorphous silicon that the "metallized" form of

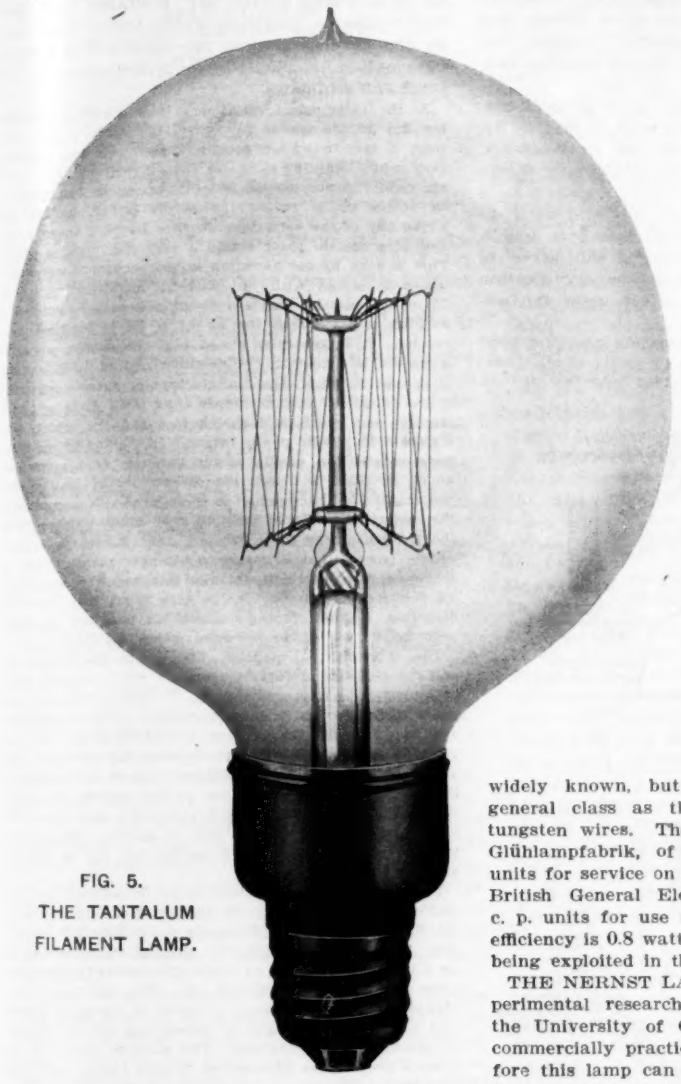


FIG. 5.
THE TANTALUM
FILAMENT LAMP.

carbon bears to the amorphous. Some physicists who have examined the Helion filament believe that the silicon is present as a carbide.

The completed Helion lamp appears similar to the common forms of carbon filament lamps. The name applied to the lamp was given because of the striking similarity of the spectrum of its light to sunlight. As was early observed, it gives off a white light at a temperature at which a carbon filament emitted only red rays. A larger portion of its light exists in those wave lengths to which the eye is most sensitive, than in the case of the carbon filament. These facts indicate that the "Helion" filament owes its high efficiency to selective radiation.

In experimental lamps, so far, units as low as 30 c. p. have been made for operation on 100 to 115 volts, with an energy consumption of 1 watt per c. p.

The resistance of the filament drops with increasing temperature until about 1,375° C. is reached (as shown by a Fery absorption pyrometer); it increases from this point to about 1,720°, and from here on again drops slightly. It has been observed that 1,720° is the point of maximum candle-power per watt, and above this temperature an increase in current does not proportionally increase the candle power. It has been suggested that a molecular change takes place, but, if so, it must occur in reverse order as the filament cools, for the phenomenon reappears indefinitely.

A small factory will be started for the manufacture of these lamps this fall. It is expected that about a thousand lamps a month can be turned out, all of which will be used for service tests. If these tests fulfil present expectations, the manufacture will be undertaken on a large scale.

Necessarily, there has been no comprehensive series of life tests. Laboratory specimens, however, have shown a useful life of 485 to 1,270 hrs. of actual burning. The lamp which showed a life of 1,270 hrs. was started at 37 c. p., 37 watts. After 200 hrs. the candle power began to increase and at 400 hrs. the lamp was rated at 40 c. p., 37 watts. From this point the intensity declined until at 500 hrs. it was normal, 37 c. p., 37 watts. At 1,230 hrs. the rating was 35.5 c. p., 36.5 watts, or an efficiency of about 1.03 watts per c. p.

THE OSMIUM FILAMENT LAMP. — The osmium lamp is the first of the new lamps, according to J. Swinburne, and credit for its invention is given to Auer von Welsbach, the inventor of the gas mantle light which bears his name.

Osmium is a crystalline, non-ductile metal of such hardness that it will scratch quartz. The process of making it into filaments is not widely known, but probably is in the same general class as those for the production of tungsten wires. The Westinghouse-Metallfaden-Glühlampfabrik, of Germany, produce 40-c. p. units for service on systems up to 75 volts. The British General Electric Co. is supplying 32-c. p. units for use on 100–130 volts. The rated efficiency is 0.8 watts per c. p. This lamp is not being exploited in the United States.

THE NERNST LAMP.—The results of the experimental research of Dr. Walter Nernst, of the University of Göttingen, Germany, became commercially practical late in the '90's. Therefore this lamp can hardly be called a new one, but as it has, by the efforts of the Westinghouse interests, been installed in very many large offices and stores, some space should be given to it in this article. Moreover, there are new developments not yet announced.

The basis of Dr. Nernst's research was the fact that many substances which ordinarily are insulators, or at least very poor conductors, can conduct current fairly well at high temperatures. Among such substances may be mentioned lime, magnesia, glass and the rare earths, so-called. Their conduction of electricity is largely due to electrolysis.

The glower of the American form of the Nernst lamp is said to consist of the oxides of several rare metals, such as yttrium, ytterbium, thorium, etc., although the true composition is known only to a few. The glowers are in the form of a short, thick filament, cemented to flexible platinum terminals by which it is suspended below and close to heating coils, which are porcelain tubes in which are imbedded resistance wires. These resistance coils are, of course, necessary to bring the glower up to a temperature where it begins to conduct. The heating resistance is connected in shunt with the glower which has in its immediate circuit an electro-magnetic switch for opening the heater circuit. When the glower becomes sufficiently heated to conduct, the current in this portion of the circuit operates the electro-magnetic switch and automatically cuts out the heating coils. On account of the large negative temperature-resistance coefficient of the glower, "ballast" is placed in the circuit. This consists of fine iron wire wound around a porcelain pencil and sealed in a glass tube to prevent oxidation at the high temperature reached. This iron wire has a large positive temperature-resistance coefficient which tends to balance the negative one of the glower, reducing the current fluctuations in the latter, and increasing the steadiness of the light.

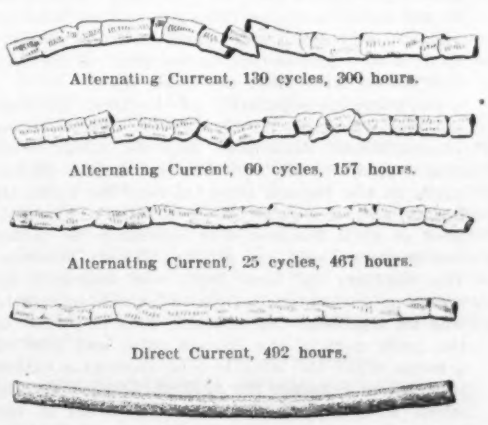
As the glower conducts electrolytically rather than as a solid, up to the present it has given a much shorter life when used on direct or low frequency alternating current circuits than with higher frequencies.

A late development of the Nernst lamp is a single-glower unit using 110 watts and giving with a clear globe 90 c. p. (mean lower-hemispherical), and with an opal globe 80 c. p. The latest development of the Nernst lamp is its adaptation to direct current circuits, but as this form is not yet on the market there are no available data and we can only make mention of it.

Nernst lamps are sold in one, two, three, four and six glower sizes, according to the need or fancy of the users. The watts per candle power decrease with the increase in the number of glowers per lamp, due to their mutual heating effects. The energy consumption of the American Nernst lamp has been stated to be between three and four watts per spherical candle power. This is hardly a fair comparison, as the Nernst lamp largely directs its light downward. An exact comparison of the ordinary and the Nernst lamp is difficult. The nearest, perhaps, is when the former is used with a reflector, giving nearly the same distribution as does the Nernst normally. The mean lower hemispherical rating of the Nernst lamp is now about 1.3 watts per c. p. The average life of the glowers approaches 1,000 hrs., with very steady voltage and high frequency.

The color value of light from a Nernst glower is better than that of the common incandescent lamp, though the light is not so white as that of an enclosed or magnetite arc. On account of the great intrinsic brilliancy of the glower, lamps with clear globes are apt to have a dazzling effect, under ordinary circumstances.

GENERAL COMPARISON OF NEW ELECTRIC LAMPS.—Dr. C. H. Sharp, Assoc. Am. Inst. E. E., Chief Test Officer of the Electrical Testing Laboratories, New York City, in a recent paper* showed the relative color values of several imported metallic filament lamps. In order to have similar figures on American lamps there has been made for Engineering News, by



Alternating Current, 130 cycles, 300 hours.

Alternating Current, 60 cycles, 157 hours.

Alternating Current, 25 cycles, 467 hours.

Direct Current, 492 hours.

New Lamp.

Fig. 6. The Appearance of the Tantalum Filament Under the Microscope After Burning its Ordinary Lifetime.

(Reproduced from Paper of Dr. C. H. Sharp, Proceedings American Institute Electrical Engineers, Dec., 1906.)

the Electrical Testing Laboratories, a series of tests similar to the first ones of Dr. Sharp. The results of the series are given in the accompanying table, which shows a color comparison with the older form of carbon filament lamp:

*Before the American Institute of Electrical Engineers, Nov. 23, 1906.

TABLE I.—COLOR COMPARISON OF NEW LAMPS WITH COMMON CARBON FILAMENT (3.1 WATTS PER C. P.).

Color Screen.	Metallized 2.5 w. p. c.	Tantalum 2.0 w. p. c.	Tungsten 1.25 w. p. c.
Clear	100%	100%	100%
Red	96.7	92.7	87.5
Yellow (Crova)	100.1	100.8	99.5
Green	100.1	103.1	104.1
Blue	105.9	114.1	128.7

The lamps, furnished by the Edison Lamp Works, were measured to determine the voltage at which they burned at their normal watts per candle, and were then photometered against an ordinary carbon lamp of the oval anchored type, burned at 3.1 watts per mean horizontal candle-power. Photometric measurements were made in the ordinary way, and also when holding colored screens before the eye, thus selecting certain spectral regions for comparison. Three glass screens were used, furnished by Zeiss. A comparison was also made using a Crova solution which, however, was found by means of a spectroscope to transmit considerable red light, a thing which a Crova screen is not supposed to do. Observations with the red and blue glasses and with the Crova screen were rather difficult on account of the low intensity, and consequently the figures given are subject to considerable error of observation.

The values given in the table are expressed in terms of the "clear" value of the old form of filament. Thus in column 2, the relative candle power of the "metallized" lamp, in the red region of the spectrum, is 96.7% of that of the older type lamp in the same spectral region, indicating that the new form has a corresponding decrease in red rays.

TABLE II.—COMPARATIVE PERFORMANCE OF INCANDESCENT FILAMENT ELECTRIC LAMPS.

	Useful life.	Watts per c. p. New.	Watts per c. p. Old.	Cost.*
Common carbon	550	3.1 to 4	4 to 6	$0.16
Metallized carbon	550	2.5	2.6	$0.20
Tungsten	1,000	1.25	1.3	$1.35 & $1.50
Tantalum	1,000	2.0	2.2	$0.45 & $0.60

*These are comparative list prices and may not be exact at any particular time. Owing to the short time the new lamps have been commercially available, these figures are to be regarded as general and approximate.

INCANDESCENT GAS LIGHTING.—It would not be presenting a just and accurate perspective of the modern lighting situation did we not make reference to the recent advances in gas lighting systems. When one considers the early Welsbach mantles, giving a green light, and compares those forms with the latest types of inverted mantle burners, giving light of good color values, it is at once apparent that material progress has been made.

The most important development of incandescent gas lighting since the introduction of the Welsbach mantle is that of the successful inverted burner and mantle. The great advantage of a better downward distribution of light and an elimination of shadow under the lamp were so attractive that persistent effort was made to produce a Bunsen burner, which would work well, upside down. The solution of this problem involved several factors. A fresh air supply must be provided with no possibility of drawing in the waste products. The gas and air must be properly mixed and still retain sufficient velocity to pass at a proper rate to the point of burning. The burner also must not flash back.

The complete separation of the fresh air supply and waste gas discharge was but a matter of mechanical design, as was the construction of a "syphon" and "race way" of correct dimensions, in the Bunsen tube between the fresh air intake and the point of combustion. Correctness of such features was necessary to insure the required velocity of the gas-air mixture. The tendency to flash back was overcome by inserting an "automatic gauze" which in reality was an ingenious thermostat. This is placed in the lower part of the Bunsen tube, and acts as a gauze while the lamp is cold, forming a slitted cone which prevents the flashing action. As the whole lamp heats up and the operation of the burner becomes steady, the chance of flashing back is minimized. The thermostat fingers then straighten out and the tube is clear where before it was obstructed by the slitted cone. The thermostatic cone is made from brass and iron rolled together, with the brass on the interior, on account of its greater expansion.

The same requirements hold here as with the older upright burner, of having a chimney to increase the draft and the light production. This chimney is of the peculiar shape shown in Fig. 7, and admits air at the ports about the bottom. By this arrangement some air must be entrained around the outside surface of the mantle, materially assisting the combustion and uniformity of light. The peculiar shape of the bottom of the chimney, provides a tray for catching particles of broken mantle.

The new inverted lamp developed by the Welsbach Co. has been called the "Reflex," and has been adapted to a greater variety of uses than was possible with the upright form. One novel feature recently brought out is the suspension of the lamp by means of a flexible tube. This tube is made from spirally wound steel ribbons and asbestos gaskets. It evidently cannot deteriorate to the extent that the old familiar rubber hose did.

The manufacture of mantles as at present carried on by the Welsbach Co. is described in detail in a recent paper* by Mr. M. C. Whitaker, General Superintendent of the Gloucester Works of that company.

Interesting as this paper is, it would be a digression to quote largely from it in this article. However, the following excerpts will serve to show the perfection to which the organization has been brought and the effect upon the advance of gas lighting.

In summing up the process for making mantles it must be apparent that it is a process of great complications. These complications may be divided into two distinct

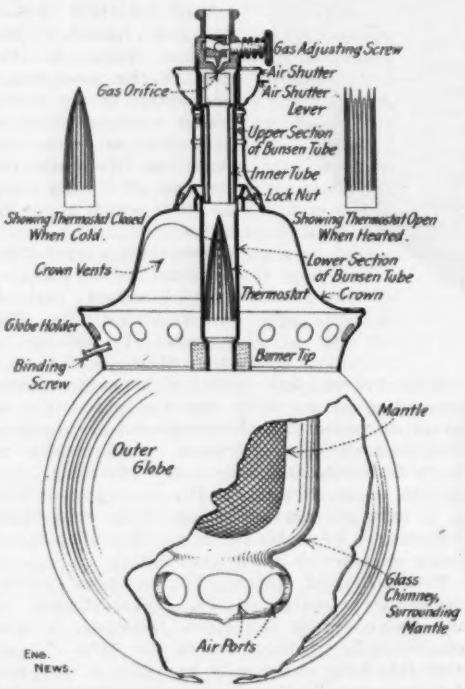


Fig. 7. Section Through an Inverted Gas Mantle Burner, Welsbach Reflex Type.

classes: the chemical problems which arise for solution and control; the supervision and control of the work of the employees in the various operations.

The first of these is under the direction of a chief chemist and staff who supervise the manufacture and use of each one of the chemical constituents entering into the mantles. For the second, it is necessary to have, not only a carefully organized staff of exceptionally efficient foremen, but also a high grade of intelligence in members of the working force, who shall appreciate the importance of the work intrusted to them.

Any impurity introduced into the mantle in any of the processes will seriously affect the finished product. The absolute cleanliness of the entire plant, of every operation and of every operator is imperative. The raw materials must be made under the direct technical supervision and control of the mantle manufacturer.

One of the most important results necessary to the user of mantles and therefore to the manufacturer is the uniformity of product. To secure this it has been necessary that the mantle manufacturer should carry his organization to a limit of perfection not realized by the maker of any other goods on the American market.

There still remains the very important duty of delivering the mantles to the consumer in the perfect condition in which they leave the manufacturer. It matters little to the consumer whether the mantle is good or bad after it has been so seriously damaged by rough and careless handling as to affect its physical life. The co-operation of the distributor of mantles is needed and solicited to bring about the successful solution of this problem. Mantles are often rendered useless by being roughly handled in transportation, or by teamsters who do not understand the fragile character of the goods. Mantles are often ruined by the fitter by carelessness or by lack of knowledge as to what constitutes injurious treatment.

*"Process of Making Incandescent Mantles"; read before the New England Association of Gas Engineers, Boston, Mass., Feb. 21, 1907. Published by the Welsbach Co., Gloucester, Mass.

During the discussion on the paper from which we have briefly quoted, Mr. Whitaker made several replies to questions which throw more light on the development of the mantle. Of all the information as elicited we present here a few pertinent sentences.

In the color effect question. It is perfectly possible for the mantle maker to control the color of the light from a mantle within certain limits. He can make a very white mantle, so white that it will not give over six candle power on six feet of gas, or he can make it so yellow as to reduce the candle power, or he may strike any of the variations of color between these points and at a certain point obtain a very high candle power. This is done by the variation in the proportion of cerium which is mixed with the thorium nitrate. Instead of 1% cerium as the standard formula it may be varied to as high as 5% and as low as 0.1 of 1% to produce these results. It is generally stated that the candle power of a mantle is higher in the neighborhood of 1.5% cerium. It is also found in the manufacture of these goods that a percentage of cerium higher than 0.8% gives a better mantle, one which will shrink less and one which will maintain its candle power longer. In the use of an ordinary mantle the candle power becomes very much reduced in time, and the less cerium or the less yellow the mantle is the quicker it is reduced. It seems that the cerium is rendered inactive very much quicker than the thorium. For these reasons, that it gives a higher candle power, that it makes a stronger mantle, that it makes a mantle which shrinks less and the fact that its deterioration on burning is very much less, make it desirable, I think, that we should all bend our energies towards the use of the so-called yellow mantle.

The indestructible mantle. The mantle manufacturers and the students of this business are giving a great deal of attention to improvements in the mantle towards the point of rendering it indestructible. It is a question whether it will ever become as indestructible as, for instance, the carbon filament, because the nature of an attenuated ash would immediately bring up to your mind that there must be limitations on the amount of stress this ash can be made to stand, and while great improvements have been made and will be made, I doubt very much if we will ever have a mantle that can be thrown around.

The three important points to be determined in connection with establishing the quality of the mantles are: (1) Physical strength; (2) candle power life; (3) shrinkage. The test to determine the physical strength is made on a bumping machine, on which the mantle is suspended after the collodion is burned off. This machine is designed to give the mantle a series of uniform shocks and its physical strength is determined by the number of shocks it will withstand. The machine used now for several years is so adjusted as to give shocks at a rate of 100 per minute.

Candle Power Test. The mantle is adjusted on a standard burner to give its maximum candle power at 2-in. gas pressure. Candle power readings are made at the beginning of the test, at the end of 100 hours, 250 hours, 500 hours and 1,000 hours of burning; 1,000 hours usually suffices to determine the comparative quality of mantles. In conjunction with the candle power test, careful readings are made of the candle power of the gas, and standard corrections are made for atmospheric conditions. The gas consumption is carefully taken at each one of the readings, and at the conclusion of the test the observations are carefully plotted for the purpose of obtaining candle power, efficiency and consumption curves for the mantle.

The Shrinkage Test. A micrometer caliper has been devised for measuring the shrinkage of a mantle at each one of the standard testing periods. The readings from this caliper are plotted and an outline showing the vertical cross-section of the mantle is made on the same sheet with the curves noted above.

It might be expected that in this article we should include arc lamp developments. The old arc gave its light by virtue of the incandescent tips of carbon pencils, while the new arc lamps owe their light-giving qualities to luminous vapors. The development of these illuminants will be treated in a later article on lamps employing luminescent gases and vapors.

In the preparation of this article, we are indebted to so many persons that we cannot here acknowledge the favors of all. However, we are especially indebted to Mr. G. F. Morrison, of the Edison Lamp Works, Harrison, N. J.

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Rarely is there compressed in a single short paper so much valuable information as may be found in the one by Mr. John D. Watson, M. Inst. C. E., on the biological treatment of sewage at Birmingham, England, printed elsewhere in this issue. Those familiar with recent developments in sewage treatment will not need to be directed to the most instructive and suggestive parts of the paper, but for the benefit of others some of its salient features may be given mention and comment.

First of all attention may be directed to the unusual amount of preliminary treatment given the Birmingham sewage for the sake of reducing the work thrown upon the percolating filters. This treatment includes screening, sedimentation, septic action and still further sedimentation—or, as Mr. Watson calls the latter, separation. Next, it is a notable fact that notwithstanding all this preliminary treatment, the percolating filters can handle less than an average of 1,000,000 U. S. gals. an acre a day. This seems high, compared with intermittent sand filtration, but low when put alongside the claims sometimes made for percolating filters.

Quite contrary to much British practice, Mr. Watson believes in "good rock or other equally durable material" for percolating filters; and also that it matters little what the material is so long as it be hard. We presume he would advise the same sort of material for contact beds, if he believed in the contact process.

The tables accompanying Mr. Watson's paper constitute the most complete and condensed presentation of the physical characteristics, the main facts of operation *and idleness*, the degree of purification effected, and the unit cost, *including capital charges*, that we have ever seen brought together for a sewage works. The inefficiency of some of the beds equipped with moving sprinklers will confirm many American engineers in their preference for fixed sprinklers.

Altogether, we think it evident that Mr. Watson's paper is worthy of careful study by all interested in the details of sewage treatment by septic tanks and percolating filters. We trust it will stimulate many other engineers and sewage works managers to compile like figures and interpretations regarding works under their charge.

That the new Public Utilities Commission for Greater New York not only "means business," but also intends to proceed intelligently is shown by numerous acts. One of the most recent, interesting and important of these is expressed in the following resolution:

> Resolved, That this commission shall forthwith investigate and examine the general condition of the Interborough-Metropolitan Co. and the Brooklyn Rapid Transit Co. and of all companies controlled by and operated in the interest of either of the said companies; their capitalization, their franchises and the manner in which their lines, owned, leased, controlled or operated, are managed, conducted and operated, including the adequacy, security and accommodation afforded by their service, and with respect to their compliance with all provisions of law; and also for the purpose of determining as the result of such investigation whether the said corporations do in fact illegally and as monopolies control and operate the several properties now under such control and operated in their interests; for the purpose of determining what is the capacity of each of the individual corporations so owned and controlled to render adequate service as required by law; and for the purpose of determining and performing the duties of this board in the premises.

The companies named own or control practically all the railway facilities on, under or above the streets of New York City. Those facilities have multiplied and have been improved (most of them) in a marvelous fashion during the past few years, yet there is great complaint of inadequate and inefficient service, and of financiering injurious to the public. Moreover, great as have been the improvements in transit facilities during the past ten years, the interests of the city, of patrons of the various roads and of the general public, have for the most part, been wholly secondary to the financial interests of stockholders—when, indeed, even these have not been sacrificed for the benefit of the inner few. In the matter of subways, to be sure, the old Rapid Transit Commission did much in behalf of all the public interests involved, perhaps as much as was to be expected under the circumstances. But besides having little control over other than subway routes, and a control of those that was narrowly limited in many essentials, the old commission was greatly handicapped in two important particulars: (1) the experimental nature of the earlier subway routes; and (2) by a conservatism which need not be discussed here and now.

The new commission inherits the accomplishments and experience of the old one. In addition, it has powers and duties far broader than its predecessor, as is evidenced by the sweeping investigation it proposes to make. But before the new commission can act with the intelligence and impartiality demanded it must become possessed of all the facts bearing upon existing transportation facilities—so far as that may be possible. These facts the resolution cited is designed to elicit.

If the new commission succeeds as fully as there is reason to hope and believe it will, we shall have for the first time, at least in an American city, a continuous technically-directed effort to secure for the citizens a unified system of local transit, designed and operated with primary regard to the needs, comfort, health, convenience and pocket books of the public, rather than to the treasury of a private corporation or the personal ambitions of the one man or the few men that control such companies in the United States.

The construction of large buildings introduces special problems relative to the handling and distribution of material, and these problems are frequently solved by the use of special apparatus and methods devised by the contracting engineers in charge of the work. The conditions to be observed include rapidity of operation, absence of interference with the structural work as it progresses, absence of interference between different processes or stages of construction, and especially economy in first cost and operation. As the work will usually occupy but a few months, it is only in an occasional case that it will be economical to make heavy investment in special plant that may not be adapted for work on future contracts. Thus the necessary combination of efficiency with low cost, and an incentive to use apparatus or equipment of general application, impose somewhat severe conditions upon the ingenuity of the engineer charged with the management of the construction. The difficulties are apt to be increased in the case of monolithic concrete buildings as compared with steel-frame buildings. In the latter, a very general practice is to use stiff-leg derricks to hoist the steel work, erecting the framework for two or three floors, and then moving the derrick up. This leaves unobstructed floors for the flooring and succeeding gangs, whose material is hoisted by elevators working in the shafts for the permanent elevators or in shafts formed by leaving out a floor panel at each floor. With concrete, however, the hoisting plant must be supported quite independently of the completed portion of the building. An arrangement which has been used in some cases is to build timber towers alongside the site, equipping these with derrick booms and material elevators. Where space is not available for this, it may be necessary to rely entirely upon elevators established within the line of the building. In either case, a considerable amount of handling may be necessary to distribute the materials to the points where they are needed.

The construction plant for an eight-story concrete warehouse building 750 ft. long is described elsewhere in this issue, and its special feature is the use of boom derricks having masts of such height that the step of the boom is carried nearly at the roof level. The 135-ft. mast is set within an 85-ft. steel-frame tower, at the top of which is a ring-bearing to support the mast laterally, and above this are the bull-ring and boom-step. For this long, narrow building, four of these derricks, with 85-ft. booms, cover the greater part of the area. The portions outside of the reach of the booms are served by gin-poles and wheelbarrows, as described. Each mast (with its tower) occupies the space of a floor panel, and the hoisting is done through the openings left for the permanent elevators and stairways. Attention may also be called to the methods of handling the various construction materials, and to the use of a portable railway system for delivering these materials to points within reach of the derricks. Railway track and equipment of this class has been extensively employed on construction work, large and small, in Europe for many years, but is only beginning to be adopted for such purposes in this country.

With reference to the arrangement of the derricks above mentioned, it is of interest to note a method which is now being used somewhat extensively in large building construction works in London, England. Three timber towers are built, each occupying the space of a floor panel, and these support a working platform above the roof level of the building. Upon the platform is a steam crane with long steel boom mounted on a turntable, and this serves to hoist material of all kinds. In some cases the crane travels to and fro upon the platform. The three-leg construction tower is so located that the crane will handle material delivered in the street below. During a visit to England last year, a member of the editorial staff of this journal saw this method in use in the erection of a number of the large and high office and business buildings, which are becoming such a feature of modern London.

THE FUNDAMENTAL PRINCIPLE OF ARTIFICIAL ILLUMINATION.

The last few years have seen a remarkable development of electric lamps, as partially sketched in this issue. It is fortunate that, with the advent of new and more efficient sources, there is a greater interest in proper methods of lighting and in the use of the new illuminants. There is now an active illuminating engineering society; several large manufacturing concerns maintain "illuminating engineering" departments; the technical press gives increased space to methods of illumination and to new illuminants. To be exact, this increase of interest in good lighting preceded the commercial forms of the new lamps. This reform has been productive of immediate and permanent good

results and promises more for the future. Much will have been gained if one basic principle already determined is put to wider use. Poor lighting is still widespread and most such can be improved if a few simple requirements can be brought broadly to the attention of engineers.

It should be understood that the principle just now being more generally applied than ever before is not itself new, but has been known since before the advent of modern electric and gas lamps. The evil results of the violation of this principle were not as widely recognized as now. Too often architects have provided beautifully wrought fixtures, very artistic and blending well with the associated design in the day time, but furnishing an illumination which is inadequate, undesirable, or both. Health demands that artificial light shall produce a minimum eye strain and fatigue. Beautiful fixtures become of secondary importance, though artistic features need not be neglected by any means.

The advent of the electric and gas incandescent lamps and the electric arc made possible an illumination not before dreamed of. With the small light-sources of earlier days, the faults of poor arrangements were not especially obtrusive, and the principles which should have governed were seen only by a few. Twenty-five years use of increasingly brilliant sources of light has shown that certain requirements cannot be neglected without injury to the eyes. The growth of the oculists' profession and lens manufacturers' business seems to have been simultaneous with the increase of promiscuous lighting. Poor methods have been followed until the troubles have become glaring. Yet a knowledge of what constitutes safe and useful illumination has been gradually diffused. Therefore when, not very long ago, an active campaign for better lighting methods was started, the time was ripe for the general movement which has resulted.

A pleasing illumination may be arranged by an ordinary good engineer in those cases where the magnitude of the work does not justify a specialist. Possibly a still more pleasing and economical effect would be produced if an expert were consulted, and where the problems are numerous and extensive, the illuminating specialist surely would accomplish the desired results quicker and cheaper than a person less highly specialized.

A study of present light sources of every type, from the candle to the latest electric lamp, would show that from the illumination standpoint alone, they can all be arranged to produce necessary illumination without seriously violating any rules which may be laid down for proper lighting. However, operating conditions may become paramount and forbid the desired arrangement. Such conditions would include fire risks, disposal of waste products and heat, cost and convenience.

There are a few rules of practice, consistent with the fundamental idea of good lighting, worth summarizing, which are entirely comprehensible to the average engineer. If these rules were more widely recognized, and more rigidly adhered to, the general advance of the art of illumination and the decrease of eye troubles, traceable to poor illumination, would be accelerated.

Illumination may be divided generally into two classes, which we may term the useful and the decorative. As extreme cases we may name the lighting of a drafting room and street decoration. It is not usually possible to entirely separate the two classes so completely. Many cases where the illumination is primarily useful, must have a certain small amount of attention paid to decorative effects. It is often desired, for instance, to so light a parlor or dining room that a required amount of illumination shall be placed where needed and yet with artistic, pleasing or even striking effects.

We propose to consider herein, only the useful applications of light in safe and sane ways, as being most interesting and helpful to engineers generally.

Pleasing and useful illumination may result from a single line of procedure. ***Seek a reasonably close imitation of daylight effects.*** The eye has been accustomed to sunlight for countless ages and so in providing artificial light the best arrangement of sources will be that which is most natural. Of course, the eye can not work in the glare of direct sunshine, but if the general properties are not imitated then the eye suffers; sometimes immediately, more often through a slow but steady process.

An analysis of natural lighting phenomena brings out several guiding conditions. We can here merely indicate some main and important features, which should be incorporated in any interior scheme of illumination.

COLOR.—The color value of the light given off by the source to be used should approach that of sunlight. A strict adherence to this is difficult, especially with the older lights, though the trouble on such an account has constantly decreased. However, less trouble results from poor color values than from other and less excusable defects. The eye seems to be least fatigued by an excess of yellow and green. This is noticed in comparing the use of dull incandescent filament lamps and mercury vapor arcs in shops. Often, when a certain degree of illumination is required, the workmen bunch a number of the dull incandescent globes, until satisfied. The eye is easily tired by working with such illumination. Similar jobs have been carried on under the light of mercury arcs without complaint, in spite of the peculiar color. The men in one foundry even declared the green light "bully" after the strangeness had passed off.

For house lighting, when a soft decorative light is especially sought, the yellows and oranges may be caused to predominate, by using colored shades or as ingenuity suggests. Such effects are not necessary for purely utilitarian purposes, and in the library, at least, a nearer approach to daylight colors will be found more agreeable after the novelty passes. As the eye is most sensitive to light rays in the yellow-green portion of the spectrum, the more the colors of an illumination scheme depart from that range the more expensive and inefficient it becomes.

DIRECTION OF LIGHT.—The eye is accustomed to light coming upon closely viewed objects obliquely from above. By such an arrangement, direct light cannot strike the retina of the eye and directly reflected light is least apt to do so. If direct or directly reflected rays, from a source of even moderate intrinsic brilliancy, do enter the eye, at least a temporary paralysis of the retina and optic centers will result. For this reason, illuminants must not be in the ordinary field of vision, or if such an arrangement be impossible they must be screened and shaded in the best way that presents itself.

Direct reflection into the eyes from dead light colored surfaces, as well as from bright polished ones, should be prevented. Many eye troubles are caused by direct reflection from papers in the office and home. The special or additional lights for reading, writing or similar work need to be far enough back of the worker so that the directly reflected rays do not come towards the eye. The old familiar rule of having light for such purposes come obliquely over the left shoulder is good.

In nearly all installations of the new lamps with their high intrinsic brilliancies, it is best to protect the eye from a possibility of harm by using frosted bulb tips and good shades and diffusing reflectors. For instance, whenever such lamps are in an occasional or possible field of vision, as near the ceiling of an ordinary room this should be done. Incidentally such a protection would soften the lighting and add to the artistic effects.

DIFFUSION.—Considerable diffusion must be secured. This necessity is obvious when one considers the painfully sharp contrasts of bright surfaces and deep shadows in the now obsolete systems of interior lighting with open arcs. It will be remembered that the replacement of the open arcs by the enclosed type, having a greater degree of diffusion, always brought some relief. The replacement of the latter, in turn, by diffusion-reflected arc and by vacuum tube lights, has been further beneficial. When the contrasts are too great the pupil of the eye accommodates itself to the brightness of the most prominent objects, so that the details are not easily discerned, if at all.

On the other hand, complete diffusion and the elimination of shadows must not be accomplished. With such a condition attained, the usual effects of light and shade are destroyed and the eye overworked to distinguish form and dimension.

Recently a scheme of placing lights known as the "cove method" of diffusion, has been used in a number of places. The arrangement is as shown in the accompanying sketch.

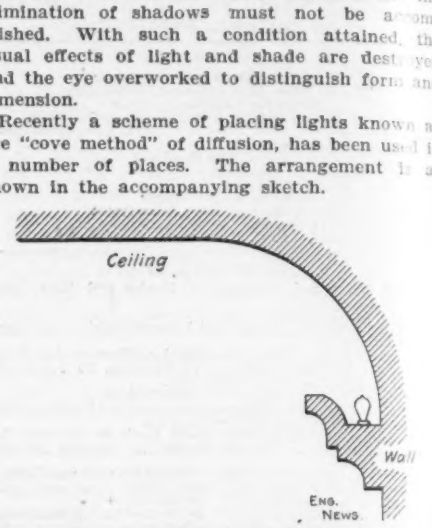


Fig. 1. The Cove Diffusion Scheme, for Indirect Lighting.

While illumination by this scheme is at first attractive from its novelty, it is found trying for continued use on account of its nearly perfect diffusion. Shadows are too completely eliminated and there is no indication as to the location of the sources themselves. On looking up from close work, it is impossible to rest the eye momentarily by looking upon darker portions of the walls or upon objects having considerable shade effects. Then, too, one naturally tries to note the location of the apparent sources of light, and a few persons find the cove scheme slightly distracting and irritating through lack of apparent source. There are places where this scheme may seem desirable, but it should preferably be instituted by a specialist who knows the effects and will be responsible for them.

SHADES AND GLOBES.—It is a fairly well established principle that light from a bright image should not fall directly upon the retina of the eye. This rules out bare incandescent filaments, glowers, or mantles. With incandescent filament lamps the shades should be so deep that the lamp is well enclosed. The proper use of shades is hygienic, and it always enhances the artistic effects.

The function of a shade or globe should be twofold: simple diffusion, and a redistribution of rays in more useful directions. The ornamental features of any and every shade and globe are subordinate to these two functions and any ornamentation they bear must not interfere with these primary purposes. Common crystal and cut glass are usually to be avoided as they do not eliminate bright spots and often their prisms deflect the light in useless directions.

One of the most useful as well as highly artistic shades that can be employed is the "holophane" type. The advantage in the use of "holophane" globes lies in their scientific and calculated construction. The diffusion and redistribution of light, left to chance in the cheaper forms of allowable shades, is here designed. The interior of the globes or shades is made up of a series of symmetrical longitudinal prisms which diffuse as shown in Fig. 2. The exterior consists of a series of lateral prisms of the general nature indicated in Fig. 3. No two of these prisms are quite alike. Their function is to redistribute the light. The entire surface of the globe or shade is an even-toned source of light, due to the effects of both kinds of prisms. There is another advantage quite as great: The small absorption of light by these globes, shades and reflectors and the relatively higher efficiency of effective illumination over that resulting from use of common opal glassware.

There are in general three classes of this glassware. One class is designed to throw the most

of the light received on its inner surface, uniformly downward. This would naturally be adapted to chandeliers and to high fixtures over library and dining tables. Another class throws the greater portion of its received light out at an angle of 45° This is for general illumination effects. The third class displays its maximum strength at 10° to 15° below a horizontal plane, and is adapted for outdoor use or for large interior areas.

The crystal appearance of holophane glass is pleasing, yet soft and restful, with no bright images. Many gas and electric interior arrangements now grossly at fault can be corrected to a wonderful extent simply by the substitution of some combination of the many designs of the classes named. Their disadvantage lies in their

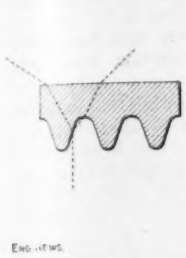


Fig. 2. Internal Diffusion Prisms of Holophane Glassware.

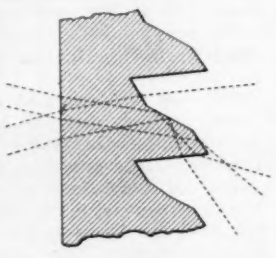


Fig. 3. Redistribution Prisms of Holophane Glassware.

capacity for collecting dust and thereby reducing their efficiency and esthetic effect. They must be well cleaned occasionally. For this purpose a long bristled brush is used. This is not a serious drawback, if one considers the time and pains expended on oil and gas lamps.

The accompanying table will give a basis for the reduction in effective candle power for lights behind glass. It does not show redistributing effect, nor the reflection in certain directions when the lamp is not fully enclosed.

Thickness of glass may, in individual cases, vary these figures which are averages of many tests on globes from various sources.

ABSORPTION OF LIGHT BY GLASS.

	Per cent.
Clear	5-10
Alabaster	10-20
Ground	20-30
Sandblasted	10-30
Opal	20-60

The average of numerous tests on holophane globes, fully enclosing a lamp, indicates an absorption of about 12% of the total light. The best any cheaper satisfactory globe can show is about 20%, with sandblasted ware.

THE AMOUNT OF LIGHT.—In order to see objects clearly the eye has always demanded a certain degree of illumination. Naturally the finer the details of the viewed object are, the more the illumination is increased. The necessary amounts of light have been determined experimentally. Such figures are merely expressions of the amount of daylight the eye has naturally for certain work. If such bonds be exceeded, the scheme becomes uselessly expensive and in some cases work is even hindered.

For brilliant interior lighting or bright house effects, an illumination of ½ candle-foot may be arranged. For more moderate and economical uses, such as we would ordinarily expect in the home, ¼ or ⅛ of a candle-foot will furnish a satisfactory general illumination, which, however, will not be strong enough for reading or for similar employment. It must be strengthened to a value of from 1 to even 4 candle-feet, depending on the nature of the occupation. Such a reinforcement may be a local one, by a well-shaded drop or reading lamp.

In special cases, the general illumination of ½ candle-foot is to be increased. In a ball-room for unusually brilliant effects, this figure may easily be 1 candle-foot. Drafting rooms have been designed for 8 to 14 candle-feet, and a minimum of 5 seems necessary for such close work.

In general, it may be said that where a room is to contain many persons the lighting needs to be stronger than it would be otherwise, and when these persons are apt to be clad in dark clothes, there needs to be a still greater increase.

An arbitrary unit of illumination has been used for several years, known as the "candle-foot." It is derived from the unit of intensity and unit of length. Thus, one candle-foot indicates the illumination that would result from a source of 1 c. p. at 1 ft. distance. For any intensity of source, the illumination at 1 ft. distance is, of course, numerically the same number of candle feet as the candle power of the source.

For a distance of more than 1 ft. the illumination varies inversely as the square of the distance. If we double the distance we quarter the illumination. This law is exactly true only in the case of light radiating from a point into space without reflection and refraction. It would apply within a small limit of error to a room with dead black walls, lighted with a single candle. In a room with light colored walls and a distributed arrangement of lamps we must consider the effects of such. In the latter case the law of inverse squares forms a basis on which to work, but is not to be considered at all exact. The law, as above stated, applies to surfaces normal to the direction of the rays of light. Expressed as a formula this would be:

$$\textit{Normal Illum.} = \frac{C.\ P.}{D^2}.$$

The case is illustrated by the surface "N," Fig. 4. For horizontal illumination, as that on a surface "H" (Fig. 4), this formula should read:

$$\textit{Horiz. Illum.} = \frac{C.\ P.}{D^2}\ \cos A.$$

when the angle "A" is that one included between a vertical, and a straight line from the source to the place where value of the horizontal illumina-

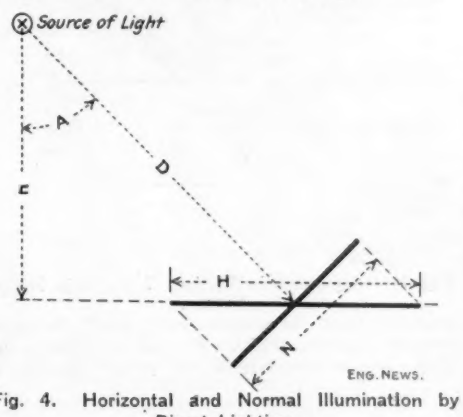


Fig. 4. Horizontal and Normal Illumination by Direct Lighting.

tion is desired. This statement will not be demonstrated as it is a well-known physical phenomenon.

It is sometimes more convenient, knowing the height (h) of the lamp above the horizontal plane of the given surface, to measure or closely estimate the angle "A" than to find the distance "D." By a simple trigonometrical process the formula becomes now:

$$\textit{Horiz. Illum.} = \frac{C.\ P.}{h}\ \cos^3 A.$$

This formula is an old one and was used by Mr. A. P. Trotter* in 1892, and is of particular use when the reflection of walls and ceilings is negligible.

In interior lighting design there are three factors which enter the calculations. These are the intensity of the source, the distance to the lighted surfaces and the diffusion and reflection effect. We have shown the law governing the first two. The last depends on the nature of the finish and fittings of the room. If the woodwork be dark and the wall finish soft and of the darker tones, then the effective illumination, on, say a printed page, is closely that number of candle-feet received from each source, as computed by the law and formula stated above. The effect of globes and shades would, of course, modify the rated candle power, as shown in the paragraphs on those fittings.

If the ceiling and the walls are not of the darker tones and softer finishes then their reflection and diffusion effect on the lighted surface may be stated very approximately as:

Candle feet

$$= C.\ P. \left(\frac{1}{D^2} + \frac{C}{D_c^2} + \frac{W_1}{D_1^2} + \frac{W_2}{D_2^2} + \frac{W_3}{D_3^2} + \frac{W_4}{D_4^2}\right)$$

where C, W_1, W_2, etc., are the coefficients of diffused reflection for the ceiling and four walls. This coefficient represents the effect each surface would have in increasing the effective candle-feet, due to the first reflection.

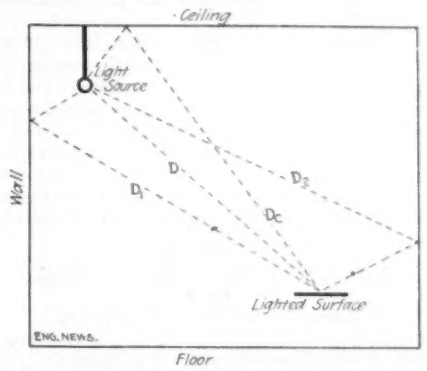


Fig. 5. Elevation Showing Illumination by Simple Reflection from Walls and Ceiling.

This method is shown by Fig. 5, for the effect of the ceiling and two walls. The effect of the other two walls would be shown on a plan of the room. The distances D_c, D_1, D_2, D_3, and D_4, are the total distance along the path of the reflected ray to the light source. When lights are well grouped they may be considered as a single source without increasing the error of the final results.

The accompanying table will show the maximum reflection effects we may expect from wall papers. Other wall finishes in general will increase or diminish the value of the reflection constant as they have relatively a harder or a softer surface than paper. These results are not directly the results of tests, but are adaptations from various sources, and are only approximate:

REFLECTION OF LIGHT FROM WALL PAPERS.

Paper.	Reflection, per ct., C.P.
Soft white	80
Chrome yellow	60
Orange	50
Dull yellow	40
Pink	35
Blue, normal bright	25
Normal green	20
Light brown	15
Dark brown	12
Vermillion	12
Green blue	12
Dull blue	12
Ultramarine blue	3

In considering reflection by this method (Fig. 5), the candle power of the source along the direction D_c may be decreased by the globe-absorption, and that along D_1, D_2, etc., may be increased by the reflection of the globe, if any. Both these are best obtained from a mean photometric curve for the particular arrangement of lamp and shade. Such curves are usually obtainable from the best lamp and shade makers.*

In many installations it is not worth while to pay too much attention to the attempted approximation of reflection effects. With the usual-sized rooms in large residences, having throughout the most favorable conditions for reflection and diffusion, with a minimum absorption, the increase of illumination on a given surface may be placed as high as 150%. Such conditions include an unbroken or unpanelled ceiling of alabaster finish, not more than 20 ft. from the floor; walls of a very light tint and a moderately soft finish; woodwork of ivory or colonial white; openings and pictures not having a large percentage of wall area; draperies, light in color

*The Distribution and Measurement of Illumination, Engineering News, Nov. 24, 1892.

*A general idea of the effects can be obtained from similar curves in "Practical Illumination," by J. R. Cravath and V. R. Lansingh.

and texture; furniture, simple, light-colored, and the room not overcrowded with even such.

These conditions are not reached in most arrangements. With ceilings, walls, furniture and draperies of the prevalent types, but of the lighter colors throughout, we cannot expect more than a 50% total increase of the direct illumination from the light sources. This value of 50% would fall nearly to zero with dark burlap walls, dark wood finishes, a panelled, somber ceiling and furniture of the dark mission styles. Where calculations of reflection are not to be undertaken, it must be left to individual judgment as to what value to assign these helpful effects between the common 50% and zero, or where the 50% may be exceeded, all depending on the predominance of color, finish and furnishings as outlined.

We have not hoped that by these brief rules we can convert a mechanical or civil engineer into an illuminating specialist, but we trust we have sufficiently indicated some rules of procedure and practice, under a simple principle, that will enable those having supervision over constructions or present installations, where a specialist would not be consulted, to see that some measures of relief from present lighting evils be instituted.

LETTERS TO THE EDITOR.

Rating Current Meters Through Ice.

Sir: In your issue of March 28, 1907, is described the rating of current meters through ice. Some years since this device was adopted when it became desirable for the State Agricultural College of Colorado to have its meters rated. We had quite a number and as a rating station was not accessible we used the same method. On a neighboring reservoir the ice was of safe thickness, of about 6 ins., and consequently a channel was cut and a sled made and successful ratings made of all the meters we had. Since then we have made a station for rating meters which can be used to better advantage during the summer season.

Sincerely yours, L. G. Carpenter,
Director and Irrigation Engineer,
Colorado Agricultural Experiment Station.

Fort Collins, Colo., July 8, 1907.

[The author of the article to which reference is made, it appears, had occasion to use his current meters in winter.—Ed.]

The Effect of High Atmospheric Humidity Upon the Setting of Concrete.

Sir: The exceptional humidity of the atmosphere in this locality recently, together with the high temperature, may be charged with being the cause of some unusual behavior of concrete in its setting and ripening, observed within a week past. A bridge inspector reported difficulty experienced through the exceedingly rapid set of concrete using a certain lot of cement of one of the most reputable American brands of Portland. The cement had been tested in the laboratory two or three weeks before and developed initial set in thirty-five minutes and hard set in five hours. The concrete, mixed wet as is our custom to facilitate embedding rubble in it, set up in the bucket so quickly that the work of compacting it and embedding the stones was very difficult. The weather was very warm and humid during the past week and the finished concrete hardened so slowly that the inspector, after a day or two, was convinced that it was defective and ordered the layer to be dug out and rebuilt. However, as examination showed the work to be well compacted it was permitted to remain for observation, and later was found to be hardening, though slowly, and was then accepted. It formed a course near the top of an unreinforced retaining wall, and great strength was therefore not essential. A retest of the cement for setting was made late on Saturday and no initial set had been found at the time of closing the laboratory though the pat had been under observation for considerably over an hour.

At about the same time it was observed on two other concrete bridge jobs—using other brands of cement—that the concrete was unusually slow in hardening, and inquiry since of other parties having developed the fact that the slow ripening has been a common experience during the past week, it seems probable that the moist atmosphere has constituted a condition resembling in a measure immediate immersion in water, operating to retard initial set.

The collapse, on July 9, of a portion of the reinforced-concrete Bridgman building in this city, though not necessarily attributable to retarded development due to exceptional weather conditions, makes it timely to direct the attention of engineers and builders to the danger of failure to make proper allowance for possible causes of retardation of the crystallizing process in concrete. There can be no doubt that disasters have been caused by the too early withdrawal of supports in cold weather, and contractors are probably learning the danger attending work in low temperatures, but it is probable that very few if any are alive to possible adverse midsummer influences. A contractor may have frequently found a certain number of days to be time enough to harden concrete girders, etc., sufficiently to maintain themselves, but he may meet atmospheric conditions that will hold back his concrete just enough short of the requisite strength to make that number of days insufficient and make all the difference between success and failure.

It may be not amiss to direct attention to another dangerous possibility—the omission of drenching with water or other prevention of too rapid drying of concrete. After it has set concrete wants water and time, and wants them together. If it be permitted to completely dry out soon after placing it will be friable—can be crumbled in the fingers, and only the action of moisture continued for a time will cure it. The time required will depend upon the degree of moisture applied. The thin girders and slabs of floors in buildings are usually subject to quick drying and they should be systematically and faithfully wetted for some days after the concrete has set. Respectfully,

Henry H. Quimby.

863 North 23d St., Philadelphia, July 12, 1907.

CONCRETE AND EXCAVATION WORK ON NEW JONES & LAUGHLIN PLANT AT ALIQUIPPA PARK, PA.

By CHARLES M. RIPLEY.*

The preliminary construction work that is now being carried on upon the new steel plant for the Jones & Laughlin Co., at Aliquippa Park, Pa.,

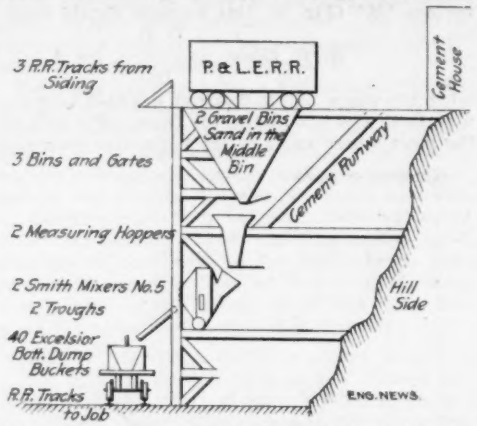


Fig. 1. Diagrammatic Section of Concrete Mixing Plant.

presents some interesting and novel features, principal among which are the excavation of blast-furnace foundations by steam shovels, a gravity-fed concrete mixing plant and a concrete-handling derrick with exceptionally wide range of action.

*108 Fulton St., New York City.

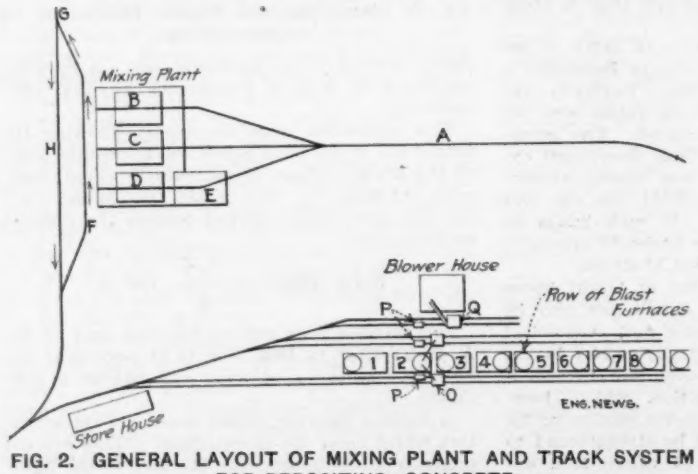


FIG. 2. GENERAL LAYOUT OF MIXING PLANT AND TRACK SYSTEM FOR DEPOSITING CONCRETE.

A—Spur to main line of P. & L. E. R. R.
B—Gravel bin.
C—Sand bin.
D—Gravel bin.
E—Cement house.
F—Point on down grade at which locomotive drops cars with empty buckets.
G—Switch.
H—Point at which cars stop waiting for locomotive.
O—Two special stiff-leg derricks with 60-ft. booms.
P—Cars containing loaded concrete buckets.
Q—Locomotive crane used for depositing buckets of concrete within narrow radius.

EXCAVATION WORK.

The plant ultimately will have ten blast furnaces with all accessories. The amount of excavation for each blast furnace is approximately 15,000 cu. yds., making a total of 150,000 cu. yds. for the furnaces, not taking into consideration the boiler house foundation, blower house, bloom mills, etc.

It will be of interest to contractors to note the results and low cost of steam shovel work for such excavation work. The excavation is made from a broad gage railroad track running through the site of the furnaces by a Marion steam shovel with 2½-yd. dipper and a Bucyrus shovel with 1-yd. dipper, digging in front and on either side. The large shovel is handled by three men, each at approximately $4 per day, assisted by four track-layers at $1.50 per day each. The smaller shovel is manned by two men at $4 per day each. There are also four more track-layers working in connection with this shovel.

The cars for excavated material are ordinary broad gage railroad flat cars, holding approximately 16 yds. each. Fifteen cars are being used in the work, and a shovel gang of eight men is provided for unloading each car. The average length of haul of dirt is 1,000 ft. to a fill, and of the total five locomotives used by the substructure contractors, three are used to haul these flat cars. The other two H. K. Porter locomotives are used to deliver materials to the mixing plant, and to haul flat cars, with Excelsior bottom dumping buckets containing concrete, from mixer to the place for depositing.

The first two furnace excavations were completed by the above method in six weeks, or about 5,000 cu. yds. per week. Each excavation pit was 300 × 75 ft. and was carried to a depth of 18 ft. below ground level. One of the great elements in reducing cost of this work, was the fact that no water or water-bearing strata were encountered and hence no pumps were required and no time wasted on this account. Neither were any piles needed for foundations, as a very hard firm gravel sufficed for this, and further did away with the necessity of sheet piling entirely.

THE CONCRETE MIXING PLANT.

As seen from Fig. 1, the 40-ft. hillside was taken advantage of in saving all hoisting expense. The expense of a skip hoist with engineer, or gang of shovelers, was done away with and all trucking also dispensed with, inasmuch as the top tracks brought materials direct from the siding, and the bottom railroad tracks took concrete direct to the job. The gang consisted of one foreman and engineer, the same man acting in the double capacity at about $3 per day, and 15 laborers at $1.50 per day. These men, with two Smith mixers, driven by the standard engine (about 19 HP.), turned out approximately 400 cu. yds. of concrete per day, proportioned 1:3:5. Of late the concreting has been going on night and day, and 800 cu. yds. for the 24 hours is not an unusual record.

Since gravity is used in all handling of materials, the requirements for steam are very limited.

The trestle work was made of 12 × 12-in. timbers and is approximately 40 ft. in height. In plan there are three tracks entering the top bench of the mixer trestle. Under each track is a bin, the two outer ones for gravel and the middle one for sand. The two gravel bins are directly over the mixer measuring hoppers and the sand bin is divided into two parts, which

each feed one mixer. Thus three bins feed two kinds of materials to two mixers. The cement bags are sent down two wooden chutes at either side of the middle track.

DELIVERING CONCRETE.

An admirable feature of this mixing plant is that one locomotive is more than able to deliver concrete to the several different locations where it is being laid, and which are widely scattered.

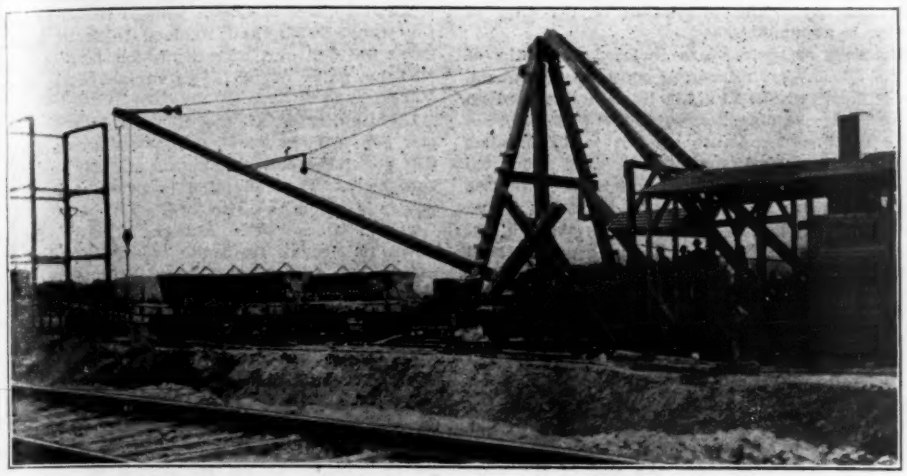


FIG 3. VIEW OF LONG BOOM DERRICK USED IN DEPOSITING CONCRETE.

This is made possible owing to a very ingenious expedient, which can be understood by referring to Fig. 2. The switching and shifting of cars in and about the neighborhood of the mixer is done entirely by gravity, thus leaving the locomotive nothing to do but drop its load of empties at one location and pick up the loaded cars at another location. By noting the direction of the arrows which indicate down-grade, it will be seen that by chocking the wheels, cars can be sent from the point where they are dropped by the engine to the point of loading, where wheels are again chocked while the buckets are being filled. Then releasing the wheels will cause the cars to run down the incline to the point G, where the grade is reversed and an automatic switch allows the cars to descend in the opposite direction to the point where they are again taken up by the locomotive.

By referring to Fig. 2 again, it will be seen how the buckets were transferred to the job from the car. Since the work lay a considerable distance from the car, two special hoisting engines and derricks of the stiff-leg variety were devised by the Carlin Machinery & Supply Co.

Owing to the limited space, the gage of these derrick cars was made 10½ ft. and the complete equipment 36 ft. long (Figs. 3-4). The A-frame or front support for the derrick mast is, however, 28 ft. wide with screws for supporting from ground after car is moved to position. By a novel and substantial method of securing the top of the mast sufficiently ahead or in front of the A-frame, the 60-ft. boom of the derrick can travel through an arc of about 190°. The machinery is designed for operating a 1-yd. clamshell bucket, using an 8½ × 10-in. Lambert special hoisting engine with three friction drums and special boom swinging attachment wherein two small drums are used, permitting all lines to clear each other freely by the original method of placing the sheaves at the bottom of the mast.

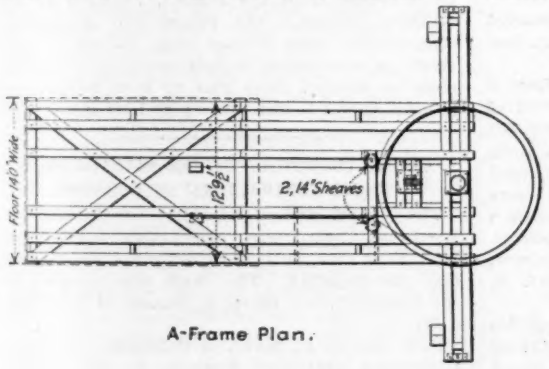
The derrick base proper is made in three parts; base plates having large surfaces for securing to timbers, the derrick base proper, which forms a seat for mast, and the removable knee or boom seat. The base has ample clearance for three ropes, its bearings being 11 ins. in diameter. The knee can be readily replaced without materially disturbing other parts of machine. The improved mast top, in addition to forming a support for the gudgeon pin, which is in front of the mast (allowing the mast timber proper to be perfectly vertical, so that it can readily be plumbed and the top and bottom bearings kept in perfect alinement) also cares for three sheaves for properly lacing the boom-raising rope. The sheave pin, in addition to its bearing in the casting, is supported by heavy steel stirrups passing through the top of the mast, with washer plates on the back. The turntable or bull wheel in this case consisted of a simple angle iron rim filled in with wood braces.

The long boom is partially supported by the boom bail secured by the end of the boom line, which has two supporting sheaves built into it for carrying the hoisting and closing lines. A simple and novel set of irons is made for the boom top lift, consisting of a long steel plate covering the two sides of the boom and passing around the end with a built-up double block for lacing the ropes. This is so designed as to give ample support for all pins, and permits all sheaves, which are mortised in the center of the boom, side by side, to be readily renewed. A simple counterweight is furnished for preventing the bucket from turning and twisting the bucket lines, which has ample range to permit of bucket digging 30 ft. below the derrick.

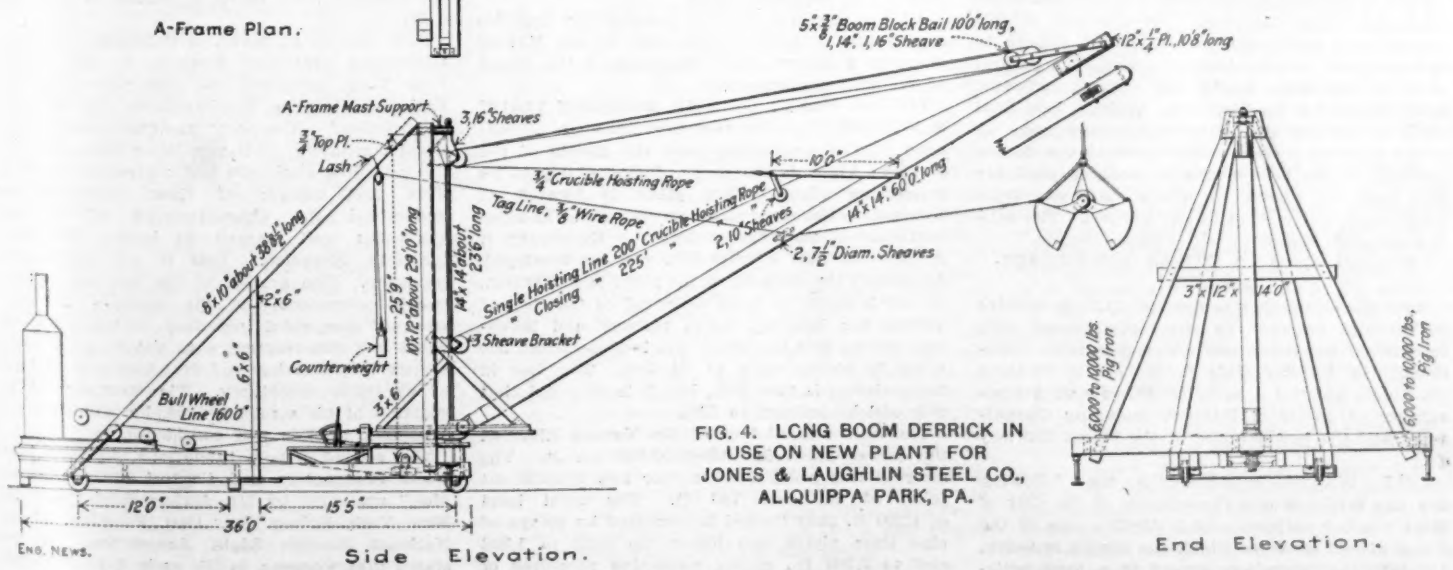
The main use of these derricks at the present time is in depositing 800 cu. yds. of concrete every 24 hours, working night and day. This concrete is dumped directly inside of the circular brick exterior walls of the blast furnace foundation.

The amount of concrete for each of the ten blast furnaces is about 18,000 cu. yds. This is greater than the amount of excavation, but the difference is made up by the fact that concreting will be carried up about 16 ft. above the ground level in certain portions of the furnace.

The blast furnace contractor is the Riter-Conley Mfg. Co., of Pittsburg and New York.



A-Frame Plan.



Side Elevation.

End Elevation.

FIG. 4. LONG BOOM DERRICK IN USE ON NEW PLANT FOR JONES & LAUGHLIN STEEL CO., ALIQUIPPA PARK, PA.

ANNUAL CONVENTION OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.*

The beginning of the 39th anuual convention of the American Society of Civil Engineers may be said to have taken place at St. Louis. Here on July 4 some 75 members and guests gathered to make their start for the long-anticipated trip to Old Mexico, where the convention was to be formally opened on the evening of July 8. As has been ordained for the summer meetings of the society, this one partook more of the nature of social and entertainment features than of a set program for the transaction of business and presentation and discussion of papers. Notable features of the stay in Mexico were the royal entertainment provided by the Federal Government, the Street Railway Co. of the City of Mexico, the leading railways of Mexico, the Mexican Association of Engineers and Architects, the Mexican members of the American Society of Civil Engineers, and

*Based on notes kindly supplied to this Journal by Mr. J. L. Campbell, M. Am. Soc. C. E., El Paso, Tex.

the local entertainment committee. Among the many good things provided by the hosts were trips about the City of Mexico and to the city water and drainage works, and to the power plant many miles distant, where electric power is generated on a large scale.

The business proceedings of the convention were held in the Minera, which historic building had been placed at the service of the Society by the Federal Government. Here the meeting was called to order at 9 p. m. on Monday, July 8, by Sr. Leandro Fernandez, President of the Mexican Association of Engineers and Architects and Minister of the Department of Communications and Public Works of Mexico. The brief exercises at this time consisted of an address of welcome by Sr. Ramon Sbarrola, of the Mexican society, and a response by Mr. Onward Bates, Vice-President of the American Society, who presided over the convention in the unavoidable absence of President Benzenberg. The address was printed in our issue of July 18.

The next business session came the following evening. Expressions of opinion regarding the place for the annual meeting of 1908 showed a majority in favor of Denver. The matter was referred to the Board of Directors. The report of the Special Committee on Rail Sections was made a special order of business for the next annual meeting. This action was due to the fact that the report was not received by the Secretary until his arrival at the convention, and therefore had not been printed and distributed in advance.

TECHNICAL PAPERS.

At a morning session on Wednesday, Mr. Geo. W. Fuller opened a discussion on the advantages of protecting water supplies by purchasing and controlling drainage areas, thereby preventing pollution, as compared with permitting a certain amount of pollution and then relying upon filtration. Broadly speaking, the conclusion of Mr. Fuller was that filtration would be necessary in any case, but that this would not obviate the necessity of keeping pollution in check. These conclusions, in the main, were supported by those who took part in the discussion.

Foundations, with special reference to conditions at the City of Mexico, was the next topic discussed. The opening remarks on this subject, by Mr. John F. O'Rourke, will be found elsewhere in this issue.

In the afternoon Mr. Geo. W. Tillson discussed the interesting question, "Will the paving materials of the present be used in the construction of the pavements of the future?" His conclusion, which was quite generally agreed to by a number of others, was that future improvements in pavements will consist in the better use of present-day materials. An abstract of this paper, with editorial comments, will appear in a later issue of this journal. The next general subject, maximum grades for electric railways, was introduced by Mr. Geo. Gibbs. The final topic of the day and of the convention came up at an evening session. It involved the double question of the best means of cleaning producer gas, and the extent to which such gas from bituminous coal is used in gas engines. The subject was introduced by Mr. James Christie.

EXCURSIONS AND OTHER ENTERTAINMENTS.

More than a week was devoted to various trips within and outside the city, interspersed with receptions, banquets and other delectable functions. On Monday, July 8, the Street Railway Co. kindly enabled a party of 300 to visit a large number of points of interest, including Chapultepec and the power-house of the Street Railway Co.

CITY WATER-WORKS.—On the following day the Water-Works Commission of the City of Mexico acted as host. At Nativitas, one of the group of springs from which the supply is taken, an elaborate lunch was served in a most artistically decorated rustic pavilion. The decoration included the American flag and the emblem of the American Society worked in flowers.

As a substitute for the present water supply, which is limited in quantity and poor in quality, the city now has well under way extensive new works. These include four groups of wells, pumping plants, a supply conduit, receiving and distributing reservoirs, and improvements to the present distribution system. Pumps at each group of wells deliver water therefrom into the supply conduit, at the termination of which another pumping plant delivers water into the reservoirs.

The four groups of springs have a total daily yield of about 2,500 liters, or 700 gals. per sec. The new works are designed to supply 48,600,000 gals. per day. The population of the City of Mexico is about 400,000.

The wells or springs are enclosed to depths of 20 to 30 ft. by reinforced-concrete chambers. The pumps, mentioned again later, are located on top of these chambers.

The reinforced-concrete conduit is 18.75 miles in length, has maximum diameters of about 6.6 ft., a flat invert, and a crown which approximates a parabola. Its hydraulic grade is .0003. Above the invert the shell of the conduit is about 5 ins. thick. The concrete is 1:3:3, made of Portland cement. Expanded metal is used for reinforcement. Stand-pipes about 30 ins. in diameter and 20 ft. high, open at the top, are located on the conduit at intervals of 333 m. (1,075 ft.). A manhole is placed in the conduit on either side of the stand-pipe. On the up-stream side there is a gate in the conduit between the stand-pipe and the manhole. There will be a normal head of 5 to 10 ft. on the conduit.

The four reservoirs, near the end of the conduit, are about 165 ft. above the streets of the city. Each reservoir is 100 meters in diameter, and has a capacity of 50,000 cu. m. (13,000,000 gals.). The walls, bottom and roof of each reservoir are of concrete, the roof slabs being supported on girders which rest on concrete columns. The central chamber in each reservoir is connected by means of a conduit with a central gate-chamber. The aggregate of the concrete for the reservoirs is similar to that for the conduit, but the concrete here is heavily reinforced with Johnson bars.

The central gate-chamber will be connected with the distribution system by a 60-in. cast-iron supply main.

The lift at each group of wells will be from 6 to 12 m. (40 to 80 ft.), and at the lower end of the supply conduit, as already stated, the lift will be 50 m. (164 ft.). At each group of wells there will be two 24-in. single-stage centrifugal pumps, and at the main pumping station there will be three pumps of similar style but with a total capacity equal to that of the eight pumps. All the pumps will be driven by electric power. The pumps are now being built by the I. P. Morris Co., of Philadelphia.

All the new water-works construction was designed and is being carried out by Sr. Manuel Marquin y Rivera, Chief Engineer of the Board of Water Commissioners.

POWER PLANT OF THE MEXICAN LIGHT & POWER CO.—For two days those in attendance at the convention were the guests of the Mexican Light & Power Co. during a trip to its generating plant. This plant is located at Necaxa, on the river of the same name, 171 miles northeast of the City of Mexico. Eventually it is expected that 200,000 HP. will be developed. At present the capacity of the plant is 40,000 HP., of which 20,000 is being delivered to the City of Mexico for lighting, street railway and industrial power, and the other half is transmitted 200 miles to stamp mills at El Oro. The loss in transmission is now 20%, but it is expected that this will be reduced to 12%.

The total annual flow of the Necaxa River at the power plant is 10,000,000,000 cu. ft. The river at this point plunges over two magnificent falls, of 460 and 740 ft. The total head of 1,200 ft. thus formed is increased by means of pipe lines above and below the falls to 1,313 and to 2,100 ft., giving respective pressures of 515 and 900 lbs. per sq. in.

The flow of the stream at this point ranges from 70 to 3,150 sec.-ft. Three dams and reservoirs are being built to provide a storage capacity equal to 50% of the run-off. The dams are of the hydraulic-fill type and will vary in height from 66 to 177 ft. The water-wheels will be supplied through 72-in. steel pipes, ¾ miles in length. There have been installed thus far six impulse wheels, each 100 ins. in diameter and carrying 24 buckets. Two nozzles in the same plane, set at an angle of 180°, deliver water to each wheel under pressures of from 535 to 565 lbs. per sq. in. The 8,000-HP. generators are mounted at the top of 14-in. shafts, the entire weight, 15 tons, being carried on an oil bearing. A speed of 300 r. p. m. is maintained. The original voltage is 4,000. This is raised to 40,000 for transmission, and reduced to from 1,500 to 2,000 for delivery. Transmission lines are carried by pairs of 50-ft. galvanized steel towers 500 ft. c. to c.

Lighting rates at the City of Mexico are 15 cts. per KW.-hr., and the power rates, $9 and $50 per HP.-year, maximum and minimum, respectively. The reduction in price of the steam power is given as 65 to 70%.

The visitors were almost literally dropped down to Necaxa from the mountains above, by means of a construction railway having 8% grades and very sharp curves. This 20-mile narrow-gage road is operated by geared and articulated engines of the Shay type.

A novel and interesting experience for the visitors was being lowered and raised over the 460-ft. and 760-ft. falls in cages accommodating 30 people. These cages have steel cable hoists and guides, extending between a head frame and an anchorage, at an inclination of about 30° from vertical. Mr. R. F. Hayward, General Manager of the Mexican Light & Power Co., and his assistants, looked after the comfort and pleasure of the party on this two-days trip.

OTHER ENTERTAINMENT.—President Diaz received the members and guests of the Society at the National Palace on Saturday, July 13. In the afternoon of the same day the Association of Engineers and Architects of Mexico gave a banquet at the National Military College at Chapultepec. This was followed in the evening by a reception in the Minera, tendered by the Military College. The palace and grounds of Chapultepec were thrown open to the visitors. Here, as everywhere during the visit of the Society in Mexico, there was no stint to the hospitality shown to the Society and its guests.

ANNUAL CONVENTION OF THE NATIONAL ELECTRICAL CONTRACTORS' ASSOCIATION.

The seventh annual convention of the National Electrical Contractors' Association was held in New York City, July 17 to 20, in the Engineering Societies Building. The chair was occupied by the President, Mr. James R. Strong, of New York City.

Prof. George F. Sever, of Columbia University, Consulting Electrical Engineer to the City of New York, presented the first paper, on "The Relations Between Municipalities and Electrical Contractors." The early manufacturers of electrical machinery, Professor Sever said, were also the installing engineers and contractors, as there were few outside of those concerns who understood the characteristics of electrical apparatus well enough to insure installation for safe operation. This is not the present condition. The growth of the business of electrical contractors and the entrance into such work of competent installing engineers has enabled the manufacturers to devote their entire energy to perfecting and standardizing all types of electrical machinery. The necessity of inspection of all contract work by municipal and insurance officials was considered.

The second paper, "Relations Between Electrical Contractors and Central Station Companies," was read by Mr. Arthur Williams, of the New York Edison Co., Past President of the National Electric Light Association. It was stated that whereas, in the early days of electric lighting, the operating companies were accustomed to make free installations of wiring and current-using devices, in order to give a wider introduction to the electrical systems, such work was now in the hands of the electrical contractors and was paid for by the consumer or the owner of the building in which the work was

down. According to Mr. Williams, free wiring and free installations of current-using devices were always unsatisfactory, as the material was necessarily of the cheapest quality, and the care given apparatus by the consumer was slight. This was stated to show the need for electrical contractors and the permanency of their business. Any increase in central station business was held to mean an increase in the electrical contractors work. Therefore it was only fair that a portion of the advertising for new business, all of which is now done by the central station companies, should be borne by the electrical contractors, on some cooperative basis. The author of this paper held that municipal and insurance inspection of electrical contractor's work was good and necessary, but did not remove the necessity of inspection by the operating company, to insure good load conditions for the station.

The last paper of this open session was read by Mr. J. R. Crouse. It was largely a repetition of one presented before the recent convention of the National Electric Light Association, at Washington, D. C., upon the phases of cooperation in the various branches of electrical industry.

At the second open session, Mr. H. T. Wreaks, of the Underwriters' Wire Inspection Bureau, New York City, read the first paper, on "Factory Inspection of Labelled Electrical Wires." He stated that the too little care in the early manufacture and installing of electrical goods caused serious fires which destroyed confidence in the safety of electric lighting systems. In spite of the great care and watchfulness of the present, fires are not eliminated though the number is smaller than with other systems. The first methods of the Underwriters' Laboratories were to receive samples of wires which were examined and reports issued from time to time on such companies as submitted samples. This scheme was successful until competition became so sharp that the general quality was not kept up to samples. Factory inspection is now maintained for wire and supplies, and material passed is properly labelled. The cost of such inspection is always less than 1% of the selling price.

"The Relation of the Technical Press with the Contractor" was presented by Mr. T. C. Martin, of the "Electrical World." Contractors must keep abreast of the times and to do so must read the technical papers. The chief value of a technical paper to a contractor lies in its construction news, its notes on practical methods, its advertising, etc.

In "The Underwriter's Relations with the Contractor," Mr. C. M. Goddard, Secretary of the Underwriters' Electric Association, traced the growth of the Underwriters' Association, of the National Electrical Code and Factory Inspection Systems.

There were several executive business sessions of the Association, and the remainder of the four days was given over to the entertainment features, which included a theater party, banquet at the Waldorf-Astoria, smoker and vaudeville, trips about Manhattan and a day's outing and clambake.

THE NEW YORK CENTRAL ELECTRIFICATION work has so far progressed that the main line service of that road in New York City, between High Bridge and Grand Central Station has been handled by electric locomotives since July 1. The change from steam to electric locomotives on both incoming and outgoing trains is made near High Bridge. The suburban passenger trains have already been electrically operated for several months. In this branch of the service motor-cars are used instead of locomotives.

The New York, New Haven & Hartford Railroad, constrained by the same legislative act affecting the New York Central, is now running into Grand Central Station by electricity. Their delay in part was caused by a disagreement over the terms of a contract by which the New York Central furnishes electric current to the New Haven road. This has now been settled and the trains of the latter now run on the New York Central power after they reach the electrified zone of the latter. Beyond this point the New Haven overhead alternating current system is used, as the New Haven motor equipment can be used on both. It is expected that this company's service will be electrically operated to Stamford, Conn., by Sept. 1.

The legislation requiring this electrification fixed a time limit at July 1, 1908. Thus both roads are practically a year ahead of the requirement.

A NEW PUMPING ENGINE now being built for the city of Milwaukee is of the vertical, triple expansion, direct-connected, crank and fly-wheel type. It is designed to pump 20,000,000 gals. per 24 hours when running at 20 r. p. m. against a pressure of 67 lbs., with an initial steam pressure of 125 lbs. by gage at the throttle. It is to develop under these conditions a duty of 162,500,000 ft.-lbs. per 1,000 lbs. of dry steam. The engine will have three steam cylinders, 30, 52 and 80 ins. diameter and 60 ins. stroke. The pistons will be double acting, and directly connected to three 33¾-in. water plungers. The steam cylinders will be placed side by side on vertical frames over the pumps. The crank shaft will have two 18-ft. fly-wheels, each weighing 50,000 lbs. The steam and exhaust valves will be of the Corliss type, except that the exhaust valves of the low-pressure cylinder will be single-seated poppet valves, operated by cams. Both the steam and exhaust valves will be placed in the cylinder heads. There will be two eccentrics for each cylinder; one for the steam and one for the exhaust valve. The motion will be transmitted to rocker arms on a lay shaft, and from this to the valve motion. The cut-off of the high-pressure cylinder will be controlled by an adjustable fly-ball governor, and the intermediate and low-pressure cylinders will be arranged to be controlled by hand devices operated from the engine-room floor. The suction pipe for the pump will be 36 ins. diameter, and the discharge pipe 30 ins. diameter. The total weight of the engine will be about 650 tons. This engine is being built by the Wisconsin Engine Co., of Corliss, Wis. Mr. Charles Poetsch, M. Am. Soc. C. E., is city engineer of Milwaukee.

NEW ADMINISTRATIVE PLANS FOR THE CANAL work, formulated by Secretary Taft and approved by the President, were made public on July 11. In brief, they provide for the transfer to the Chief of Engineers of the army of the supervision of purchases of material and supplies; the maintenance of offices within the United States by the Canal Commission to facilitate the execution of its business; the appointments, in the United States, of the Commission's employees to be made by the General Purchasing Officer under Civil Service rules; and the abolishment after Aug. 15 of the provision for general auditors and local auditors, and the appointment for the Commission upon the Isthmus of an examiner of accounts with an assistant in Washington.

A STEAMSHIP DISASTER on the Pacific Coast on Sunday morning, July 21, caused the loss of 50 to 100 persons of the crew and passengers of the steamship "Columbia." The latter was a steel steamer running between San Francisco, Cal., and Portland, Ore., and was bound north with about 250 persons on board. A smaller wooden steamer, the "San Pedro," southbound, ran into the "Columbia" in misty weather off northern California, and broke a hole in the "Columbia's" side. The larger ship sank rapidly. About 150 persons were taken off the steamer before it sank, and some others were rescued from lifeboats which were later picked up. The "Columbia" was 309 ft. long, 38½ ft. in beam, and 14½ ft. deep, with a tonnage of 1,750, and was built in 1880. At the time of the San Francisco earthquake (April, 1906) the vessel was lying in the dry dock of the Union Iron Works, and was capsized by the earthquake. Since then the vessel had been completely refitted.

A CURIOUS STEAMSHIP ACCIDENT occurred to the "Kaiser Wilhelm II." of the North German Lloyd, while coaling at Bremerhaven, on July 20. The ship heeled over to one side and took in a great amount of water, which entered the engine-rooms and the coal bunkers. One man is said to have been drowned. The vessel was not seriously endangered, and pumping out was promptly started. One round trip to New York and return are canceled in consequence of the accident.

COLLISION WITH AN ICEBERG off the Newfoundland Banks, on the night of Sunday, July 7, narrowly missed sending to the bottom the fast North German Lloyd liner "Kronprinz Wilhelm." Fog prevented discovery of the berg until the vessel was close upon it. The course was changed suddenly, making the impact a glancing one; the bow of the vessel sliding upon a submerged shoulder of the berg, striking a slicing blow and dropping off again. No damage was done beyond slight abrasions of the bow plates and some breakage of the deck forward from falling fragments of the berg upon it.

IN THE COLLAPSE OF "CRYSTAL HALL," a 4-story brick building in London, Ont., over 20 people were buried on July 16. A number of those buried were killed. The building was being remodeled; some old supports had been taken out and iron girders had been placed, the foundation becoming weakened in the process.

HIGH WATER WRECKED A BRIDGE over the Monongahela River just above Pittsburg, Pa., on July 17. The bridge was under construction. A rise of some 6 ft. in about 10 hrs. swept out the falsework. Reports put the loss at $100,000. Damage by floods is reported from all of the mountain region of western Maryland, West Virginia, western Pennsylvania and Ohio. The Baltimore & Ohio Ry. had many sections of track washed out. At many points bridges and buildings were wrecked or washed away.

A DRAWBRIDGE ACCIDENT at Marinette, Wis., on July 18, resulted in blocking navigation and tying up several vessels above the bridge. The steamer "Carolina" of the Goodrich Line struck the draw-span of the lower bridge over the Menominee River, causing it to drop into the channel. The bridge tender claims that the steamer did not whistle for the bridge to be opened.

A HEAD-ON COLLISION on the Pere Marquette R. R. on July 20, near Salem, Mich., resulted in the death of more than 30 people and the injury of about 70 more. The collision was between a special excursion train, loaded with road employees on their annual outing, and a freight. The officials of the road state that it was a clear case of forgotten orders on the part of the freight crew.

IN A REAR-END COLLISION on the Third Avenue Elevated Ry., New York City, on July 16, 21 persons were injured. The motorman claimed that rioters in the front car crowding against his door and into the booth, prevented his shutting off the power; his train crashed into one standing at the 106th St. station.

THE SUNBURY COLLISION on the Pennsylvania R. R., noted on page 47 of this volume, has been investigated by a Coroner's Jury which reported on July 13. Blame was placed on the railroad company for not having an interlocking switch at the point where the collision occurred.

THE SAN BERNARDINO (Cal.) ROUNDHOUSE of the Atchison, Topeka & Santa Fe Ry., a building 30 years old, collapsed on July 4 and buried 10 engines. There were 38 men at work at the time, but they heard preliminary sounds of the collapse and all escaped. The company intended tearing down the roundhouse in a short time.

A DAM WAS DYNAMITED in Louisiana on July 20, for the second time. The dam was built across the Mermentau River, near Crowley, La., for the Rice Irrigation & Improvement Association. The structure was described and illustrated in Engineering News of Sept. 28, 1905. It was completed in October, 1904, at a cost of $125,000, and after having been blown up in 1905 it was reconstructed. The structure, which was of timber and included a movable dam and lock, was designed to shut out salt water, at low water, from canals serving as a supply to irrigate rice fields. The dam was also designed to prevent the overflow of lands at other times. It was designed by Maxcy & Anderson, of Houston, Tex. Reports state that at the second dynamiting, on July 20, more than 100 masked cattlemen overpowered 12 guards on the structure shortly before sunrise, and succeeded in wrecking 170 ft. of the dam. The cattlemen claimed that the dam caused the overflowing of their pastures.

THE PANAMA CANAL will have the sides formed by channeling machines in the rock sections, according to a decision of the Isthmian Canal Commission. This includes almost all of the wet prism in the Culebra Division, nine miles long, and also the walls of the locks at La Boca and Mira Flores. Among the advantages to be gained from channeling are, that the wall is solid and unbroken by explosives, and is cut exactly to the surveyed line; no subsequent trimming or filling is needed, as in the case of a wall cut by drilling and blasting. For this work the Commission has ordered 24 Sullivan channelers, fitted with air reheaters. They are similar to those used on the Chicago main drainage canal and its extensions, but are larger and more powerful, and able to cut more rapidly.

CAUTION IN HANDLING INFLAMMABLE MATERIALS is called for by new rules just put in force by the Pennsylvania R. R. On the ends and sides of every car that carries inflammable materials are placed cards reading, "Inflammable—Keep Lights and Fires Away." Whenever it is possible, tank cars, loaded or empty, which contain or have contained inflammable substances, must be placed ten cars away from the engine and five cars from the caboose in a freight train. Cars loaded with charcoal or explosives must not be put next to cars bearing the "Inflammable" sign.

At every stop of a freight train the crew must make special examination of cars for hot boxes, when inflammables are on board. When cars with such freight are

received from "foreign" roads the yard master or agent at the junction point must see that the cars are properly carded.

The label for packages contains the following directions in large, black letters:

"Caution. This pacakage must be carefully handled. It must not be loaded or stored near a radiator, stove or any other source of heat. Lighted lanterns, matches, and all other flames must be kept away from it. Do not expose to the sun."

A COLLIERY EXPLOSION at Toyo Oke, Bungo Province, Japan, is reported to have killed over 400 out of 470 miners underground on July 20.

PERSONALS.

Mr. W. P. Feeley, Assistant Engineer of the Peoria & Eastern Ry., has resigned.

Mr. W. J. Eck has been appointed Electrical Engineer of the Southern Ry., to succeed Mr. G. W. Johnston.

Mr. A. B. Morton was recently appointed Manager of the Municipal Lighting Plant at Wakefield, Mass.

Mr. A. B. Stickney has been appointed Assistant Superintendent of the San Joaquin division of the Southern Pacific Ry., at Bakersfield, Cal.

Mr. Geo. P. Carver has opened offices in the Exchange Building, 53 State St., Boston, for consulting work in reinforced concrete construction.

Mr. W. F. Owen, of New Orleans, has been appointed General Manager of the Mobile, Jackson & Kansas City R. R., and Assistant to the President.

Mr. C. B. Scott, Assoc. M. Am. Soc. C. E., has accepted a position as Resident Engineer with the Virginia State Highway Commission, with headquarters at Lynchburg.

Prof. L. E. Young, of the Chair of Mining at the Colorado School of Mines, has been elected Director of the School of Mines of the University of Missouri, at Rolla, Mo.

Mr. E. Le B. Gardner, M. Am. Soc. C. E., of Paterson N. J., has been elected to succeed Mr. John V. Cockroft as President of the Consolidated Water Co., of Utica, N. Y.

Mr. Walter S. Woods, City Engineer of La Crosse, Wis., has resigned to accept a position as Chief Engineer of the La Crosse Water Power Co., which is building a large plant on Black River.

Mr. William Graham, Assistant Engineer of Bridges and Buildings for the Baltimore & Ohio R. R., has resigned to accept a similar position with the New York, New Haven & Hartford R. R.

Mr. C. C. McCain, Commissioner of Lake Lines at Buffalo, has been appointed Chairman of the Trunk Line Association, with headquarters at New York. The appointment will go into effect Oct. 1.

Mr. G. I. De Wolf, Superintendent of Terminals for the National Lines of Mexico, has been appointed Engineer of Maintenance of Way of the International R. R. with headquarters at Ciudad Porfirio Diaz.

Mr. J. D. Underwood, Assistant Engineer of the Bureau of Water, Pittsburg, has resigned to become Hydraulic Engineer for the National Board of Fire Underwriters. His resignation will take effect on Aug. 1.

Mr. W. R. Newton, of Yorkville, Ill., has tendered his resignation as a member of the Illinois & Michigan Canal Commission, to take effect at once or upon the appointment of his successor by Governor Deneen.

Mr. W. D. Wheeler, Division Engineer of the Minneapolis & St. Louis Ry. and the Iowa Central Ry., has been appointed Chief Engineer, succeeding Mr. H. G. Kelley, who is now Chief Engineer of the Grand Trunk Ry.

Representative T. E. Burton, of Cleveland, is reported as resigning from the Chairmanship of the Rivers and Harbors Committee of the House, to devote his time to the Inland Waterways Commission, of which he is Chairman.

Prof. Royal P. Jarvis, M. Am. Inst. M. E., head of the Department of Mining Engineering and Metallurgy at the Washington State College, has resigned and will accept the corresponding position with the University of Tennessee.

Mr. Otto Dieckmann has been appointed Manager of the St. Louis sales office of the Atlas Engine Works, of Indianapolis. He has been their representative at St. Louis for some time, and will retain his offices in the Chemical Building.

Mr. A. C. Brower has been appointed Engineer of the Wichita Division of the Missouri Pacific Ry., to succeed Mr. E. C. Welch. Mr. Welch takes a similar position with the St. Louis, Iron Mountain & Southern Ry., at De Soto, Mo.

Mr. E. B. Carter has tendered his resignation, effective July 31, as General Roadmaster and Engineer of the Florida East Coast Ry., to become Engineer and Manager of the U. J. White Co., which is engaged in developing the Haw Creek properties near Dupont, Fla.

Messrs. Chas. Iffer & Co., general contractors and builders in reinforced concrete and heavy construction, have just opened offices at 1161 Broadway, New York City. Mr. Iffer has for the last five years been connected with the General Supply & Construction Co. of New York City as Manager, and within the last year as Treasurer.

Mr. L. W. Jones resigned on July 8 as President and Director of the Pittsburg Filter Mfg. Co. He has been connected with that company since 1903; in the near future he expects to open an office in Pittsburg as Consulting Engineer, specializing in municipal and industrial filtration plants, and water softening and sewage disposal plants.

Mr. Josiah Gibson, M. West. Soc. E., formerly in charge of railway bridge detailing with the Wisconsin Bridge & Iron Co., of Milwaukee, has accepted a position as Chief Draftsman with the Southwestern Bridge Co., of Joplin, Mo. Mr. Gibson is the author of the end shear table, in Engineering News for June 21, 1906, for calculating bridge stresses under wheel loads.

Mr. John F. Carney, formerly with the Selling Department of the McCrum-Howell Co., of New York City, and for the past year Manager of the Heating Department of the Barstow Stove Co., Providence, R. I., has become Manager of the Eastern Branch of the National Regulator Co., makers of heat regulating devices, with offices at 1135 Broadway, New York City.

Mr. A. Jordahl has joined the engineering staff of W. S. Barstow & Company, Engineers and Contractors, 50 Pine St., New York City. He will be in charge of the reinforced concrete work at the New York office of the latter company. Mr. Jordahl is a graduate of the Technical College of Trondhjem, Norway, and was formerly with the Reinforced Cement Construction Co., of New York City.

Mr. Frederick A. Waldron has established an office as a Consulting Industrial Engineer at 35 Wall St., New York. He will be concerned in such matters as the selection of profitable factory sites, the designing of new factories and power plants, the preparation of reports on existing power and industrial plants and designs for their modification, the effecting of economies in shop practice and improvements in shop organization.

Mr. John F. Stevens, M. Am. Soc. C. E., formerly Chief Engineer of the Panama Canal Board, was on July 19 appointed a Vice-President of the New York, New Haven & Hartford R. R. He will have charge of all matters pertaining to the operation of the road. For some time Mr. Stevens has been engaged in the work of revaluation of the entire property of the New Haven system, which will be completed by Aug. 1; on that date he will take up his new duties, with offices in New Haven.

Prof. Wm. F. M. Goss, M. Am. Soc. M. E., has resigned his position as Dean of the School of Engineering and Director of the Engineering Laboratory at Purdue University, Lafayette, Ind., and has accepted the position of Dean of the College of Engineering at the University of Illinois, Champaign, Ill. He has been connected with Purdue University for a number of years, and was mainly instrumental in the establishment and operation of the locomotive testing laboratory, the valuable work of which is well known.

Mr. E. O. Falkner, Manager of the Tie and Timber Department of the Atchison, Topeka & Santa Fe Ry., will go to Australia in September to remain about two years, making a study of the growth and habits of the eucalytpus tree to determine its adaptability to culture in America as tie timber. Unsatisfactory experiments with concrete and steel ties are back of the plan. Mr. Falkner has acquired a reputation as an authority on tie timber, and has superintended large tie-treating plants for the Santa Fe.

Messrs. Maurice Gesundheit and Henry Osgood have entered partnership as a firm of manufacturing engineers and "business methodizers," with offices at 43 Cedar Street, New York City; the firm name is the Gesundheit-Osgood Co. Mr. Gesundheit is a civil and mechanical engineer of considerable business experience in the line of manufacturing and industrial work, accounting systems, etc. Mr. Osgood, through broad commercial experience—banking, advertising, etc.—brings to the firm the essential qualifications in that direction.

Mr. Mortimer Grant Barnes, M. Am. Soc. C. E., of New York City, has been appointed by Governor Hughes as a member of the Board of Advisory Engineers for the New York State Barge Canal, to succeed Mr. Elmer L. Corthell, M. Am. Soc. C. E., resigned. Mr. Barnes is a graduate of the University of Michigan and has had wide canal experience; he has served as Assistant Engineer on the Panama Canal Division of Locks and Regulating Work. He is at present employed by the Board of Water Supply of New York City in connection with the Catskill Reservoir.

The members of the Massachusetts State Board of Boiler Rules, a board created by the legislature this year, were recently confirmed by the Governor's council. The appointees are Joseph H. McNeill, of Melrose, Chairman; Wm. M. Beck, of Everett (for three years); John A. Stevens, M. Am. Soc. M. E., of Lowell (for three years); Frederic H. Keyes, M. Am. Soc. M. E., of Newton (for two years); and Robert J. Dunkle, of Boston (for two years). Chairman McNeill is Chief Inspector of the Boiler Inspection Department of the Massachusetts District Police; Mr. Beck, formerly a locomotive engineer with the Boston & Maine R. R., is Master Mechanic of the Knickerbocker Ice Co., on the Kennebec River; Mr. Stevens is Chief Engineer of the Merric Manufacturing Co., of Lowell, and allied interests, and is the holder of eight patents on boilers; Mr. Keyes is General Manager for the Robb-Mumford Boiler Co., at South Framingham; Mr. Dunkle is a member of the insurance firm of O'Brion & Russell, of Boston, and devotes his attention particularly to the boiler, accident and liability branches of the business. The Board thus embodies representatives of the boiler manufacturing, boiler using, operating and insurance interests.

Obituary.

Henry Lewis Carter, President of the York Haven Water & Power Co. and the York Haven Paper Co., of Pennsylvania, died on July 16 in New York City, at the age of 50. He originated the large York Haven dam, built at a cost of $3,000,000.

Joel Mable, a prominent southern civil engineer, died of pneumonia in Atlanta, Ga., on June 25. He was 65 years old, and for 30 years had been engaged in civil engineering. He was connected with the location and construction of many southern railroads, and was Resident Engineer of the old and new water-works of Atlanta.

Prof. Angelo Heilprin, of Philadelphia, a scientist of international reputation, died on July 17 at the home of his sister in New York City. He was a well known explorer, and his death was due to a tropical fever contracted in South America some years ago. His specialization was in the direction of paleontology and geology; his devotion to the latter took him up Mount Pelee, while it was still in eruption after the destruction of St. Pierre, Martinique. He was born in 1853 at Satoralja-Ujhely, Hungary, and came to America when but three years old.

ENGINEERING SOCIETIES.

COMING MEETINGS.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
See special notice below. Secy., Edw. A. Moseley, Interstate Commerce Commission, Washington, D. C.

ILLUMINATING ENGINEERING SOCIETY.
July 30-31. First annual meeting at Boston. Secy., Dr. A. H. Elliott, 4 Irving Place, New York.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Aug. 7-9. Annual meeting at Norfolk, Va. Secy., Frank P. Foster, Corning, N. Y.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 27-30. Annual convention at Chicago, Ill. Secy., W. O. Thompson, Oswego, N. Y.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 10-13. 38th Annual Convention at St. Paul, Minn. Secy., A. P. Dane, Boston & Me. R. R., Boston, Mass.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.—The time and place of the next convention (given in our last issue as July 29, at Seattle) have been changed to Oct. 8, at Washington, D. C. The change seemed advisable in view of the resignation of Hon. John McMillan, President of the Association; Mr. C. C. McChord, Vice-President, will complete the convention program and assume, pro tem, the duties of the President.

THE MACHINERY CLUB is a new social organization now being formed in New York City to bring together those connected with various branches of the machinery and metal trades. The club is to occupy the 20th and 21st floors of the Fulton Terminal Building at Church and Cortland Sts., now under construction. The officers of the club are as follows: F. H. Stillman, President; R. C. McKinney, Vice-President; Walter L. Pierce, Treasurer; Theodore Waters, Secretary. Board of Governors—O. C. Gayley, Second Vice-President Pressed Steel Car Co.; John W. Dunn, President International Steam Pump Co.; George A. Post, President Standard Coupler Co.; Walter L. Pierce, Secretary and General Manager Lidgerwood Mfg. Co.; F. H. Stillman, President Watson-Stillman Co.; Charles A. Moore, President Manning, Maxwell & Moore; James B. Brady, Vice-President Standard Steel Car Co.; R. C. McKinney, President Niles-Bement-Pond Co.; J. W. Duntley, President Chicago Pneumatic Tool Co.; Thornton N. Motley, President Thornton N. Motley & Co., Inc.; Henry Prentiss, President Prentiss Tool & Supply Co.; John R. McGinley, President Duff Mfg. Co.; A. B. See, President A. B. See Electric Elevator Co.; W. H. Marshall, President American Locomotive Co.; Arthur L. Merriam, President Ames Iron Works; E. H. Wells, President Babcock & Wilcox Co.; W. L. Saunders, President Ingersoll-Rand Co.; Otis H. Cutler, President American Brake Shoe & Fdy. Co.; J. R. Vandyck, President Vandyck Church Ill Co.

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